A SIMULATION BASED COMPARATIVE ANALYSIS OF ALTERNATIVES

FOR TUITION ASSISTANCE ORGANIZATIONAL STRUCTURES

THESIS

Tamiko L. Ritschel, Captain, USAF

AFIT/GOR/ENS/03-20

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GOR/ENS/03-20

A SIMULATION BASED COMPARATIVE ANALYSIS OF ALTERNATIVES FOR TUITION ASSISTANCE ORGANIZATIONAL STRUCTURES

THESIS

Presented to the Faculty

Department of Operational Sciences

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Operations Research

Tamiko L. Ritschel, BS

Captain, USAF

March 2003

AFIT/GOR/ENS/03-20

A SIMULATION BASED COMPARATIVE ANALYSIS OF ALTERNATIVES FOR

TUITION ASSISTANCE ORGANIZATIONAL STRUCTURES

Tamiko L. Ritschel, BS
Captain, USAF

Approved:

__________________//signed//__________________ __24 Jan 03__
Paul W. McAree, Maj, USAF (Chairman) date

__________________//signed//__________________ __4 Mar 03__
Dr. John O. Miller (Member) date

__________________//signed//__________________ __4 Mar 03__
Dr. James T. Moore (Member) date

Acknowledgements

I would like to recognize my thesis advisor, Major Paul McAree, for his help and support throughout the course of this thesis effort. I would also like to express my thanks to my other committee members, Dr. John O. Miller and Dr. James Moore, for their direction and assistance. My sponsor, AF/DPLE, also deserves recognition for the unending support and insight they provided during the entire thesis process.

I would be remiss if I failed to mention the endless support and encouragement my husband has provided throughout this process. The example he set with his own thesis efforts and the support he provided throughout mine was instrumental in achieving my goals as a master's student.

Tamiko L. Ritschel

Table of Contents

List of Figures

List of Tables

AFIT/GOR/ENS/03-20

Abstract

The military services have experienced enormous downsizing efforts in the last decade. With these initiatives, organizations have had to derive innovative ways to meet their objectives with fewer resources. An organization's structure is an avenue to address these challenges within the atmosphere of a shrinking capital budget. Organizational structure changes can affect every aspect of the organization. Such an impact suggests proposals for drastic organizational changes must meet the rigors of a full analysis.

The intent of this research is to provide a comprehensive analysis of centralization options for Air Force Tuition Assistance efforts. This thesis effort involves the development and subsequent analysis of multiple simulation models. The models provide insight into whether or not centralization will produce savings in processing times, manpower, and cost.

Results show that centralization will positively impact the Tuition Assistance organization in meeting their objectives while allowing the Air Force to take advantage of efficiencies through technological advancements.

A SIMULATION BASED COMPARATIVE ANALYSIS OF ALTERNATIVES FOR TUITION ASSISTANCE ORGANIZATIONAL STRUCTURES

1. Introduction

1.1 Overview

A critical decision facing senior management executives is the challenge of finding the best organizational structure for optimizing the objectives of their business model. The science of Operations Research (OR) has developed a myriad of techniques that provide management with the objective information needed to justify critical organizational structure decisions. The current business environment mandates a reaping of the benefits OR analysis provides. Phrases like “streamlining”, “rightsizing”, “outsourcing”, and “downsizing” are shaping the future for businesses across the United States. This paradigm shift to a leaner, streamlined business model is evident in the Department of Defense (DoD) through manpower cuts of 40% from 1986 to 1997 and fundamental changes in the structure of the armed forces (Fogleman, 1997). These changes result from an attempt to meet the responsibility of providing for the defense of the United States under the constraints of a reduced capital budget (McCain, 2002). An excellent example of DoD’s endeavor to embrace this paradigm shift is the issue of centralizing military Tuition Assistance (TA) in the United States Air Force (USAF). The TA program provides funds to active duty military members who seek off-duty educational credits for personal and professional advancement.

1.2 Background

The Air Force's TA efforts are headquartered at the Air Staff within the Air Force Education Division (AF/DPLE) located at the Pentagon. Seven active duty Major Commands (MAJCOMs) in the Air Force have personnel dedicated solely to the TA program and report program activity to the Air Staff. The MAJCOM offices oversee the TA responsibilities at each of the 82 Base Education and Training Flights situated under their respective commands. Some offices report directly to the Air Staff because they are not situated under a MAJCOM, and conversely, some MAJCOMs do not have bases designated under their command. These units are considered Direct Reporting Units (DRUs), and they function as both a base level office and as a MAJCOM with respect to their responsibilities. The local Base Education and Training Flights and the DRUs work directly with the student concerning all TA related matters. Figure 1 illustrates the current organizational structure for planning and execution of military TA. This structure is comparable to the Air Force Administrative Control (ADCON) Structure (Barry, 1998).

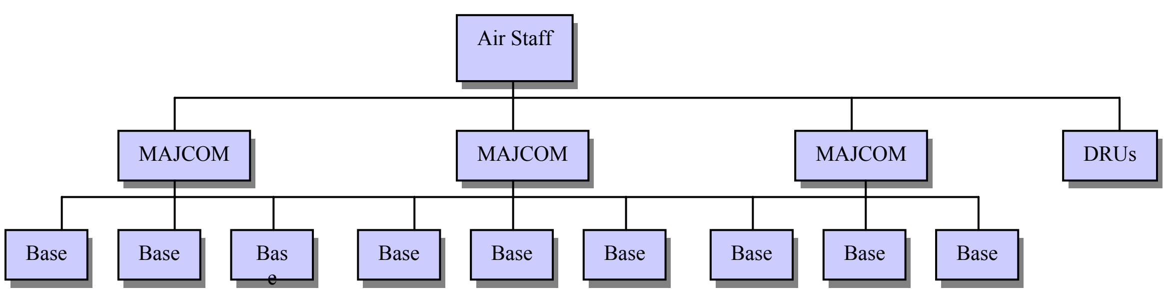

Figure 1. Air Force Tuition Assistance Organizational Structure

AF/DPLE is examining alternative organizational structures for managing TA. Several issues must be addressed in evaluating the alternatives. AF/DPLE is particularly concerned with gaining efficiencies with respect to manpower, processing times, and cost

in the execution of TA dollars, as well as process efficiencies in the budgeting process. The budgeting of TA dollars occur within the framework of the Programming, Planning, and Budgeting System (PPBS) process. The PPBS is the DoD's process of programming, planning, and budgeting funds for future years. This process is laborious and time consuming for every organization involved and inputs are currently required from the lowest levels of the organization. TA funds flow from the Air Staff to the bases through the structure found in Figure 1. This decentralized approach to funds management results in situations where some bases face underfunding throughout the span of a fiscal year (FY).

In 1997, the Air Force began privatization efforts for the Base Education and Training Flights through DoD's Competitive Sourcing Program (AF/DPLE, 2002). OMB Circular A-76 mandates that the government seek goods and services from the private sector when cost savings will result. During this process, the government develops the Most Efficient Organization (MEO) based on contract requirements. The MEO competes against private offerors for the contract award (A-76 website, 2002). Many proposed MEOs downsized in anticipation of a centralized TA system. The centralized system concept was in consideration due to the Navy's successful centralization efforts in the early 1990s (AF/DPLE, 2002). However, in order to properly assess the validity of a centralized technology-based education management system for the Air Force, a thorough study needed to commence.

The Navy, the Marine Corps, and the Coast Guard have successfully centralized their TA programs and benefited from significant cost savings (Taylor, 2002). Many large corporations have also found centralizing aspects of their business sector

advantageous in regards to effectively managing their information assets. One example is that of the Amoco Corporation, who several years ago centralized their corporate accounting functions. This effort helped generate tremendous economies of scale and improved document maintenance (Amoco Corporation, 2002). Experiences of companies like this and the different service components provide a benchmark for the analysis required to determine if the Air Force should centralize TA efforts. They also provide insight into the best organizational structure to meet the needs of today's Air Force.

1.3 Problem Statement

The existing Tuition Assistance organization presents several issues of concern for the Air Force community. First, the current flow of TA funding is riddled with inefficiencies that are believed to be contributing to manpower excesses and task redundancies (Baker, 2001). Second, it is hypothesized that processing times are lengthy and payment procedures are more complicated than necessary under the current organizational structure (AF/DPLE, 2002). Furthermore, the Base Education and Training Flights are failing to recoup the TA funds owed the government for dropped or failed courses. Rectifying this problem alone could amass millions of dollars in dividends for the Air Force. In addition, inefficiencies and inaccuracies in the PPBS process within the current organization are contributing to equity of service concerns for the student. Finally, the existing archaic TA system cannot take full advantage of technological advancements, and this prevents the Air Force from keeping pace with the changing state of business.

The centralization of Tuition Assistance is the proposed solution to these problems. This research analyzes the impact of centralization on the aforementioned areas of concern.

1.4 Research Objectives

The objective of this research is to quantitatively determine if the Air Force should centralize the financial aspects of military TA. The three major categories of interest for this analysis are time efficiencies, financial savings, and manpower savings. This research focuses on answering the following questions:

- Will centralization save the Air Force processing time?
- Will centralization save the Air Force money?
- Will the Air Force reap benefits from manpower savings?
- Does the proposed centralized system supply an adequate manpower resource?

The answer to these questions is the key to adequately analyzing the centralization proposal.

1.5 Methodology

This research involves the development of multiple simulation models representing the current system and the AF/DPLE proposed system. Additional analysis includes plausible ideas formed throughout the model building process to suggest improvements to the proposed system. The simulations are utilized to examine the time, cost, and manpower efficiencies of the different systems. The output from the simulation models is examined using statistical analysis to determine which systems provide the most benefit to the Air Force.

1.6 Scope of Research

Air Staff has proposed an organizational plan for the implementation of centralization (Baker, 2001). This research is limited to comparisons between the proposed plan, the current system in place, and any potential new organizational plan based on ideas formulated during this research process. The analysis is limited to a quantitative assessment of the four research questions presented above.

1.7 Thesis Overview

Chapter 2 covers the background of the problem in more detail to provide a better understanding of the problem. Relevant past research and success stories within the context of business-oriented simulation efforts and centralization studies is also presented in Chapter 2. Chapter 3 describes Law and Kelton's 10-step process for the implementation of a successful simulation. Chapter 4 implements the 10-step process as a framework in explaining the model development and implementation involved in this research effort. The advantages and disadvantages of centralization with regard to the PPBS process are discussed in Chapter 5. Chapter 6 presents results and conclusions from the research effort.

2. Literature Review

2.1 Chapter Overview

This chapter details the fundamental concepts and techniques necessary in our approach to determine the best TA organizational structure. In Section 2.2, an overview of the Air Force's TA program is presented to include a brief discussion of the current organizational structure, an explanation of the application process, and a description of the proposed Centralized Tuition Assistance (CTA) organization. In Section 2.3, the two major Financial Management aspects of TA, the PPBS process and funds execution, are presented. This begins with a cursory overview of the PPBS process followed by details on the aspects of the PPBS and funds execution processes affected by centralizing TA. In Section 2.4, a review of best practices with regards to organizational structure and process design is examined. The chapter concludes by addressing the applicability of simulation as a tool to make appropriate and accurate organizational structure decisions.

2.2 Tuition Assistance Background

The TA program is one of the most popular benefits available to military members. Currently, the Air Force, along with the other service organizations, authorizes 100% payment of TA for active duty military members. This payment is capped at $250.00 per semester credit hour up to a maximum of $4,500 per fiscal year for voluntary off-duty education (Keating, 2002). The implementation of 100% TA began on 1 October 2002. Prior to this date, TA paid for up to 75% of school course expenses. Students may use TA funds to pursue voluntary professional certificates, licenses, or

degrees up to the masters-level during their military career. The degree sought must be an advancement beyond the student's current educational level. An education plan must be approved by the Education Services Officer (ESO) and filed at the base office prior to authorization (Department of the Air Force, 2000). The ESO ensures that the enlisted member's retainability extends beyond the completion of the course or the officer's date of separation (DOS) is two years or more beyond the course completion date. If the officer's DOS is before the two year point, an Active Duty Service Commitment (ADSC) extension for the service member is required and updated with the Military Personnel Flight (MPF). Students owe reimbursement dollars to the government for TA funds if they fail to successfully complete a course. Waivers for reimbursements are granted for unanticipated health problems, Temporary Duty (TDY), Permanent Change of Station (PCS), change in work schedules, or emergency leave situations (Department of the Air Force, 16 October 2000).

Current TA Organization.

Currently, all TA related efforts are conducted at the base level with oversight at the MAJCOM and Air Staff level. TA efforts are situated under the functional area of the Education and Training Flight. The Education and Training Flights are currently undergoing a series of outsourcing studies to determine if their efforts should be contracted out. These studies, often referred to as *A-76 Studies*, are in conjunction with the Office of Management and Budget (OMB) Circular No. A-76 which states that:

> In the process of governing, the Government should not compete with its citizens. The competitive enterprise system, characterized by individual freedom and initiative, is the primary source of national economic strength. In recognition of this principle, it has been and continues to be the general policy of the Government to rely on commercial sources to supply the products and services the Government needs. (Office of Management and Budget, 1999)

As a result of the A-76 process, the base education office organizational structures are not homogeneous across the Air Force at the present time. Some organizations are structured under the MEOs, others are contracted out, and some have yet to undergo the A-76 study. Despite this difference, each of the bases have positions that may vary in title, but conduct virtually the same range of duties. Each base level office has an ESO that handles the administration efforts of the entire Education and Training Flight. Base Education Technicians service customers that come into the Education and Training Flight seeking TA funds. They perform quality control on all TA applications by verifying completeness, accuracy, calculations, and data entries (Base Education and Training Flights and MAJCOM Representatives, 2002). Education Technicians keep track of TA funding, reconcile school invoices, pay invoices, handle waivers, resolve owed reimbursements, and forward AF Form 1227s – Authority for Tuition Assistance to the Air Force Personnel Center (AFPC) for officers who incur an active duty service commitment (AF/DPLE, 2002). There may be multiple specialists handling these jobs at the base level. At least one Education Technician will be a Government Purchase Card (GPC) holder. This person has the additional duty of paying all invoices and reconciling the GPC statement at the end of each billing period. The ESO usually acts as the approving official for the GPC holder (Base Education and Training Flights and MAJCOM Representatives, 2002). The chart in Figure 2 gives a general model of the

organizational structure found at the base level. The blocks noted as *inherently governmental* refer to positions that cannot be contracted out due to job descriptions that require activities that are “so intimately related to the exercise of the public interest as to mandate performance by Federal employees” (Office of Management and Budget, 1999).

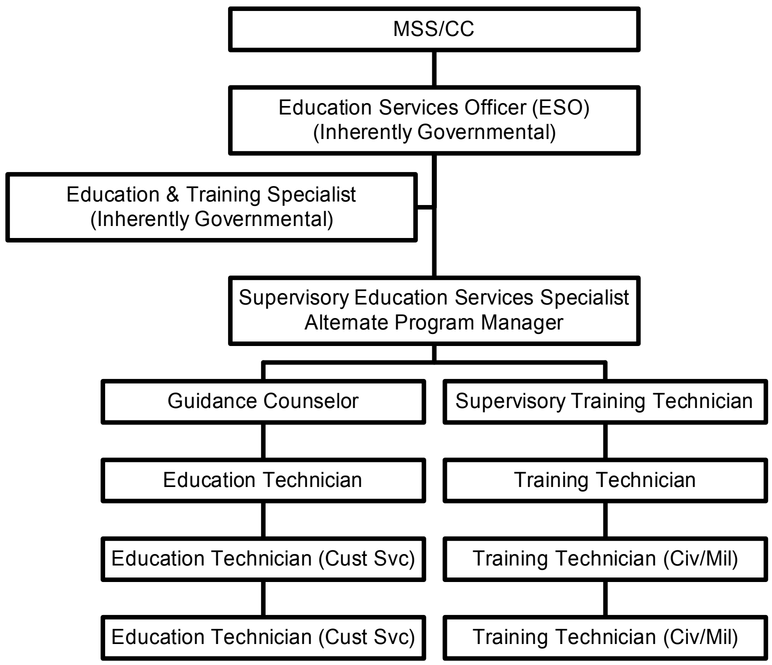

Figure 2. Education and Training Flight Organizational Chart (AF/DPLE, 2002)

At the MAJCOM level, there is one person dedicated to handling TA policy and regulation issues for the base offices located under their respective command. This person also has the authority to approve waiver appeals that do not fit the authorized exceptions for waivers (Base Education and Training Flights and MAJCOM Representatives, 2002). Additionally, a financial manager is located at the MAJCOM level to oversee TA funds execution at all the base level offices. The financial manager allocates TA funds to each of the bases and has the authority to take money from one

base and dispense it to another base in response to fiduciary concerns (Base Education and Training Flights and MAJCOM Representatives, 2002).

Application Process.

Under the current TA structure, the application process for TA begins with a student entering the Education and Training Flight to fill out AF Form 1227, Authority for Tuition Assistance-Education Services Program. In addition to completing the AF Form 1227, the student is required to have an Education Plan on file before TA is approved. The Education Plan details the necessary courses to complete the degree being sought. The degree requirements of the educational institution drive the Education Plan; however, the plan has flexibility in areas such as elective credits. There are education counselors located at the Education and Training Flight to assist students in making the appropriate decisions in regards to their Education Plans. Additionally, these trained professionals provide counseling in a myriad of other educational opportunities (e.g. commissioning programs). After the student has successfully applied for TA, they return to their educational institution of choice to enroll in their course. During this enrollment process, the student submits paperwork to the school with instructions to bill and send final grade reports to the proper Education and Training Flight.

Once the course is successfully completed, the student is required to return to the Education and Training Flight to submit their grades. If the student fails to successfully pass the course, they are afforded the opportunity to apply for a waiver through the Base Education and Training Flight. If the waiver is not for an approved reason listed in AFI 36-2306, the student may appeal to the ESO for a waiver. If a waiver is not granted, the student is required to reimburse the government for the TA funds. An AF Form 118 –

Refund of Tuition Assistance Education Services Program, is sent to the student with three options to reimburse the government: cash payment, a lump sum payroll deduction, or payroll deductions spread across a specified number of months. If the student does not respond to this request, the lump sum payroll deduction will transpire (Base Education and Training Fights and MAJCOM Representatives, 2002). Although these are standard operating procedures, some education offices stray from this formula. The procedures for collection of reimbursements is a major area where the Air Force particularly struggles with standardization, as revealed by interviews conducted during the course of this research and surveys initiated by AF/DPLE. It is one of the hypotheses of the proposed centralization that standardization of these procedures will bring in more TA funds owed the government through reimbursements. Investigation of this hypothesis is found in subsequent chapters.

Centralized TA Organization Proposal.

On 22 October 2001, in a Staff Summary Sheet submitted by AF/DPLE, a plan was proposed for the implementation of Centralized Tuition Assistance (CTA). This plan was submitted in an attempt to alleviate the problems TA has with inefficiencies, recoupment of reimbursement dollars, and equity issues for the student (Baker, 2001). Additionally, a proposed centralized tuition assistance organization was designed to provide the Air Force with the opportunity to reap benefits in technological advancements in the area of data management and web-enabled business processes (Baker, 2001). As the technology and the organization develop, there will be a move to an entirely web-based TA procedure. In this proposed plan, all TA transactions will eventually be executed through the Air Force Virtual Education Center (AFVEC).

AFVEC will allow a student to logon to the Air Force Portal to access their education information and apply for TA online (Baker, 2001). Students will be able to access information from the home or office about courses taken, current degree plans, fiscal year caps, and their Air Force Education Record (AF Form 186). AFVEC will also provide on-line test and appointment scheduling, a school directory, and course catalogs for students to utilize (Baker, 2001). Because the centralization of TA is so intimately tied to funds execution, a detailed examination of the proposed CTA process follows the discussion on Financial Management and the PPBS Process.

2.3 Financial Management and the PPBS Process

If centralization of TA efforts is deemed the best organizational structure, a portion of the Planning, Programming, and Budgeting System (PPBS) Process within the TA sector will be streamlined. This section provides a brief description of the PPBS process to provide background for the study. The purpose of the PPBS is to provide structure to the process of allocating government funds within the DoD. The PPBS was first introduced in the early 1960's by then Secretary of Defense (SECDEF), Mr. Robert McNamara (Defense Systems Management College, 2001). There are three phases to the PPBS process. The Planning Phase involves determining the forces and resources required to appropriately handle the defense needs of the United States. In the Programming Phase, resources are allocated by priority level to best meet these needs under the constraints of manpower, force, and fiscal assets. In the Budgeting Phase, the Service Agencies and Office of the Secretary of Defense (OSD) thoroughly examine their

budgets to ensure appropriate use of restricted fiscal resources (Defense Systems Management College, 2001).

Several documents are critical for the PPBS to operate efficiently. The Future Years Defense Program (FYDP) is a database of all resources associated with programs under control by the SECDEF. Thus, the FYDP is considered the most vital document in the PPBS process (Defense Systems Management College, 2001). "The FYDP is usually updated three times during the PPBS cycle: in May to reflect the Service Program Objective Memorandum (POM) submission; in September to reflect the Service Budget Estimate Submission (BES); and in January to reflect the President's Budget submission" (Defense Systems Management College, 2001). Despite original designs to apply the PPBS cycle on a biennial basis, in practice the process is executed annually. Though the PPBS cycle is very extensive and complicated, it is important to note that TA centralization will affect only a small aspect of the process. It is imperative to understand these facets of the PPBS process to fully comprehend the changes that will occur if TA efforts are centralized.

During the Programming Phase of the PPBS, each Military Department and Defense Agency submits a POM to the SECDEF in May of the even-numbered year (an Amended Program Objectives Memorandum, or APOM, is submitted in the odd-numbered years). As a precursor to this document, base level organizations generate a Financial Plan (FIN Plan) that is used to construct the POM at the higher levels. This document presents the department or agency's allocation proposal of available resources to satisfy the Defense Planning Guidance (DPG), which is a product of the Planning Phase. The following summary chart outlines the timeframe for submittal of key

documents during the Planning and Programming Phases of the PPBS Process (see Figure 3).

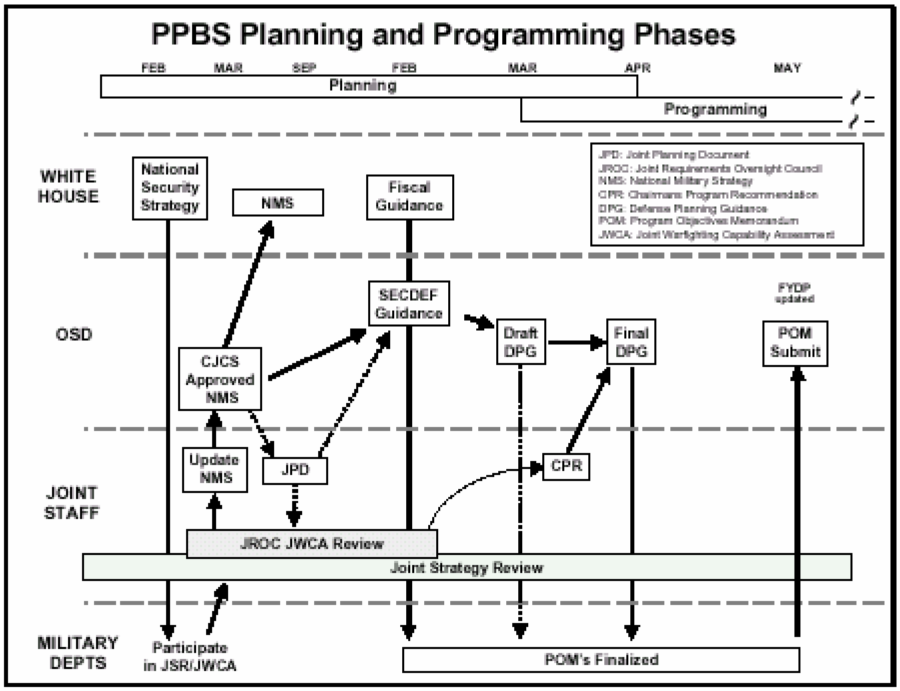

Figure 3. PPBS Planning and Programming Phases (Defense Systems Management College, 2001)

During the Budgeting Phase of the PPBS, the individual organizations begin developing their budgets in anticipation of requests from headquarters. The Services aggregate their submissions and convene a Summer Budget Review to internally justify their budget. The final product is the Budget Estimate Submission (BES), which is forwarded to the Office of the Secretary of Defense (OSD) in September. This submission goes through a review and reclama process before it is rolled into the President's Budget. The President's Budget is finalized in early January and presented by the Office of Management and Budget (OMB) to Congress by the first Monday in February. The budget then enters the Congressional Enactment phase, which marks the end of the PPBS cycle (Defense Systems Management College, 2001).

The actual PPBS process will not change if TA undergoes centralization, but the way the TA organization handles its required POM and BES submissions will undergo modifications. Currently, the lowest levels of the TA hierarchy are involved in the PPBS process. Before the May POM submission is due to the SECDEF, each TA sector of the Base Education and Training Flights puts together a FIN Plan that outlines required funding for the following fiscal year (AF/DPLE, 2002). Subsequently, the FIN Plan is sent for funding consideration to the base's respective MAJCOMs. The MAJCOMs then aggregate the figures for submission to Air Staff. A second instance where the lowest levels of the TA hierarchy are currently involved in the PPBS process involves the BES. Before the BES is due in September, the base level TA organizations are tasked to provide budget estimates to the MAJCOMs (AF/DPLE, 2002). Once again, this information is amassed for presentation to the Air Staff. This decentralized approach to the POM and BES is necessary because the current knowledge base and data required for these taskings is only available at the lowest levels.

The proposed centralization of TA will result in several changes to the current process. Centralization of TA will provide a central database that will empower personnel at the Air Staff level with the knowledge to derive the principal documents of the PPBS cycle (AF/DPLE, 2002). Under the current TA organizational structure, bases often face the predicament of being underfunded. Funds flow down to the MAJCOMs and then to the bases. If necessary, the MAJCOMs have the authority to redistribute funds between the bases. However, funds cannot be redistributed between the MAJCOMs. Centralization would mean there is one pot of money for TA across the Air Force. Any underfunding issues would then require immediate resolution or TA would

be put on hold for the entire Air Force. For these reason, AF/DPLE anticipates that centralization could help to alleviate the chronic underfunding problem within the current TA organization.

Funds Execution.

The preceding discussion on the PPBS cycle details the process that leads to funds appropriation. Funds execution is the other side of Financial Management. Each approval of a TA application results in the government committing money to a particular educational institution. These monetary commitments are subject to the Antideficiency Act, Title 31, U.S. Code, Sections 1341 and 1517. The Antideficiency Act forbids government officials from obligating funds in advance of appropriations or without adequate funding authority (Department of Defense, 1998). This signifies that TA funds must be available for obligation before TA application approval. Under the current TA organization, each base has a separate TA appropriation. Due to the underfunding problems previously discussed, ESOs often face the dilemma of breaking the Antideficiency Act, which carries penalties of fines and imprisonment, or denying TA funds to students.

Denying TA funds carries its own set of difficulties for the ESOs. TA funding is a benefit promised to active duty service members. Denying members this right often causes grievances filed with the Base Commander all the way up to Congressional members (Base Education and Training Flights and MAJCOM Representatives, 2002). Although this is not a uniform problem across all bases, this predicament does occur for ESOs from time to time at various Air Force installations. It is important to understand this problem can be chronic for some bases, and ESOs have different philosophies for

handling this situation. This reveals a genuine equity issue for the military member. While a student at one base may be denied TA funds, a student at another base will be approved. Centralization may be an avenue to correct this equity issue. Under centralization, TA funds will materialize from the same appropriation. Therefore, all military members, regardless of their current installation, will be afforded an equal opportunity to utilize these funds. Additionally, the severity of TA underfunding issues will become a higher priority due to increased visibility when the whole Air Force is facing a standstill in TA funds, as opposed to one installation.

Other areas in which funds execution is a predominate concern include: TA approvals, school billings and payments, and reimbursements for failed or dropped courses. Currently these transactions transpire solely at the base level. Under centralization, these activities will be relocated to one central office with limited base involvement. Students will apply for TA online by accessing and filling out AF Form 1227, Authority for Tuition Assistance, through AFVEC. The AFVEC system will validate the military member is eligible for TA by checking fiscal year caps, outstanding TA debts, retention information for enlisted and ADSCs for officers. AFVEC will also ensure the student has a current education plan on file (AF/DPLE, 2002). If these exit criteria are met, the student's request is compiled and sent with a listing of all TA requests to a counselor for review at the base level. The counselor will conduct a final check to ensure all the requirements of AFI 36-2306 are met before approving TA. Once a request has been approved, the student will receive an e-mail notice with the TA approval attached (AF/DPLE, 2002).

The student is responsible for taking the TA approval, complete with billing information, to the school for enrollment. The CTA office will receive all invoices from the educational institutions. They will then validate each invoice and reconcile discrepancies before authorizing payment (Baker, 2001). A GPC holder at the CTA office will make the payment. Additionally, the CTA office will receive and verify grade information. If the student receives a passing grade, an e-mail will be forwarded to the student with the grade information and the TA process is considered complete (AF/DPLE, 2002). If the student fails to successfully complete their course requirements, they will be sent an AF Form 118 – Refund of Tuition Assistance. They will then have the opportunity to pay in cash, have deductions taken from their pay, or apply for a waiver by forwarding the form to the base TA office with documentation of the AFI-approved exemption. If these conditions are not met, the Air Force will automatically begin collections from the military member's pay (Baker, 2001). The following figure diagrams the process as it is intended to work under the CTA concept (see Figure 4, on the following page).

2.4 Relevant Centralization Success Stories

In the early 1990s, the financial administration of the Navy's TA Program was centralized under the direction of the Naval Education and Training Professional Development and Technology Center (NETPDTC), located in Pensacola, Florida (Myatt, 1997). The improvements the Navy experienced under the centralized organization prompted the Marine Corps to join efforts with the Navy in 1994 (Myatt, 1997). NETPDTC established a cross-functional team in 1990 to review integral aspects of the

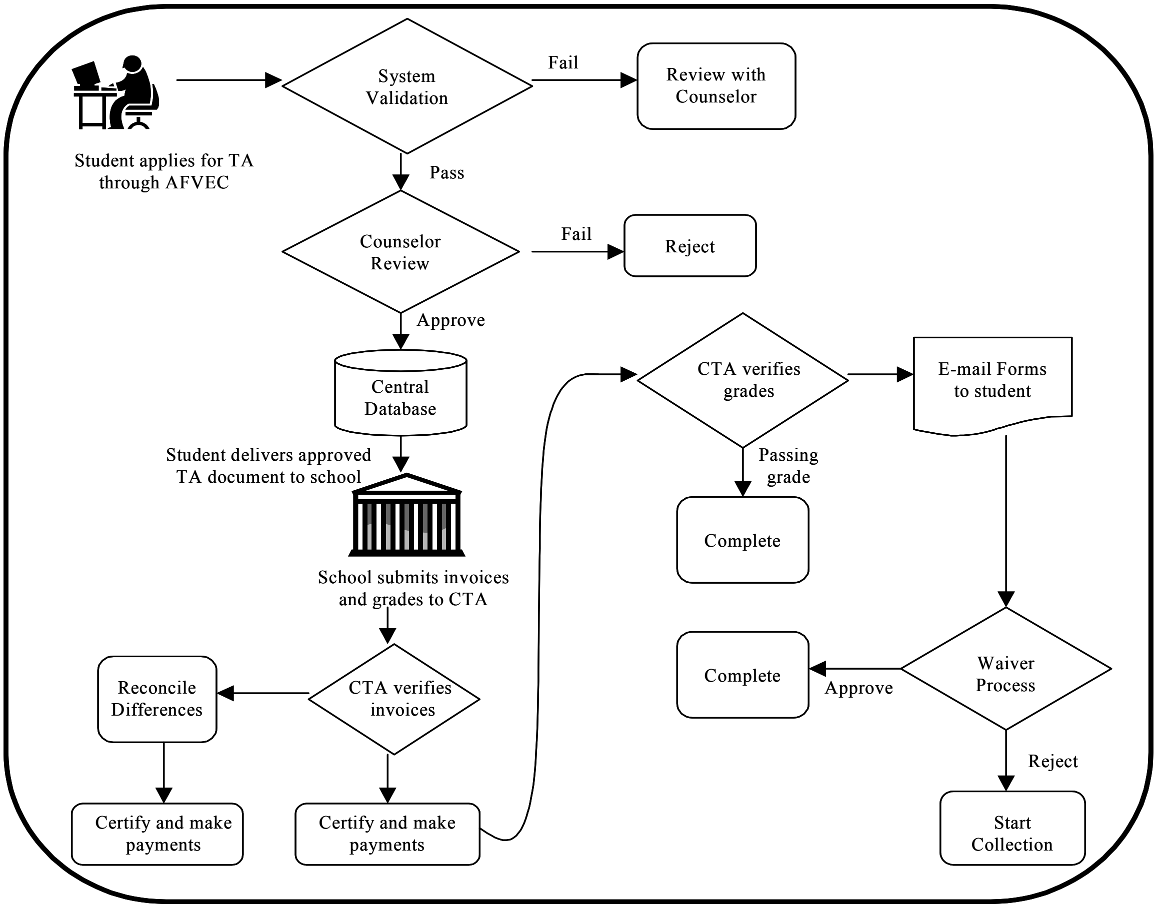

Figure 4. Central Tuition Assistance Procedures (AF/DPLE, 2002)

TA process in the hopes of streamlining efforts, improving process times, and increasing collections on reimbursement dollars. The team found that millions of program dollars were being lost due to overpayments to colleges and universities, untimely processing of course cancellations and grades, and failure to collect on reimbursements owed to the government (Myatt, 1997). Before the centralization was initiated, all accounting, grade processing, and enrollment actions were administered at over 50 regional offices and base education centers around the world. This decentralized organizational structure made it difficult to standardize procedures and assign responsibility and accountability (Myatt, 1997). Untimely, inconsistent, and sometimes nonexistent processing of school refunds

and collections from students was the consequence of these shortcomings. In some years, this mismanagement of funds led to a loss of as much as $3 million (Myatt, 1997).

One of the major steps the Navy took to resolve these ongoing problems involved organizational changes. They chose to centralize accounting, grade processing, and enrollment verification at NETPDTC. "This resulted in more effective, responsive, and accountable oversight and financial support of the program" (Myatt, 1997). Freeing up this responsibility from the bases allowed the base education center personnel to focus on their primary responsibility of counseling the students. These improvement efforts have led to over $20 million in savings for the U.S. Government in the six years after the implementation of Navy centralization. The Marine Corps came online in Fiscal Year (FY) 1995 and experienced approximately $3 million in savings in their first two years of operation, despite their TA program being less than half the size of the Navy's (Myatt, 1997). It is these kinds of savings that the Air Force anticipates it will be able to take advantage of with the implementation of a centralized organizational structure.

2.5 Organizational Structure and Process Design

Organizational structure decisions are prevalent in the business world as demonstrated by the wealth of literature available in this area. A government organizational structure decision provides a unique situation that cannot categorically take advantage of advancements in business practices. However, business practices can be benchmarked and lessons can be learned from large corporations. These lessons have resulted in businesses centering around a process-oriented approach to organizational decision making that was made popular in the 1990's (Lind, 2001). Under this approach,

a process has been defined as a complete set of activities that together create value for the customer. Thus, large businesses are increasingly recognizing the key to competitive survival is investigating business processes (Aguilar, Rautert, and Pater, 1999). Lind supports this theory when he states, “in order for organizations to remain competitive in an ever-increasing business climate there is a need for organizations to develop their business performances” (Lind, 2001). Companies have tried to do this through a myriad of different approaches such as Total Quality Management (TQM). “Common to all these approaches is that they focus on business processes” (Lind, 2001).

The Dell Corporation provides an excellent example of how process-oriented business management brought huge success to a personal computer (PC) manufacturing organization, producing $12 billion in company assets in just 13 years (Aguilar, Rautert, and Pater, 1999). Dell concentrated its efforts on analyzing and improving the process of providing a PC to the customer. The process was surprisingly simple yet highly effective and efficient. One of the keys to success for Dell was focusing on inventory cycle times instead of on inventory size (Aquilar, Rautert, and Pater, 1999). They were able to condense distribution channels by removing one of the distribution levels (Ahlfors, Kalermo, and Karkkainen, 2000). This provided Dell the opportunity to decrease their inventory time to 11 days, allowing them to be ahead of their competitors by 69 days. The improved process allowed Dell to offer better services and move to internet-based sales. Customers could order PCs personalized to their needs over the Internet. This enhanced process affords Dell the ability to begin assembly after the order has been received, thereby leading to better customer service and satisfaction (Aguilar, Rauter, and Pater, 1999).

This customer-approach paradigm shift has led to the success of business process design (Aguilar, Rautert, and Pater, 1999). Essentially, this paradigm was born out of the belief that better business processes will lead to improved customer satisfaction that in turn lead to larger profit margins. The government organization provides a unique perspective in the respect that there is no concern for profit. Profit gains or losses cannot be used to measure the organization's improvement. Nevertheless, how better to measure organizational performance than through process enhancement? This is exactly the measure and focus the government requires to benefit from the efficiency and effectiveness gains that the business sector has enjoyed for the last decade.

2.6 Simulation

A valid and popular method that takes advantage of a process-oriented approach to investigating system performance is simulation. Simulation involves using a computer software program to evaluate a system numerically, and gather data in order to estimate the true system characteristics (Law and Kelton, 2000). "Applying modeling techniques like simulation allow the analyst to test new operating procedures, decision rules, organizational structures, and communication flow without disrupting ongoing operations" (Pegden, Shannon and Sadowski, 1995). Law and Kelton provide an excellent example of why simulation is a useful tool in the following excerpt:

> As an example of the use of simulation, consider a manufacturing company that is contemplating building a large extension onto one of its plants but is not sure if the potential gain in productivity would justify the construction cost. It certainly would not be cost-effective to build the extension and then remove it later if it does not work out. However, a careful simulation study could shed some light on the question by simulating the operation of the plant as it currently exists and as it *would* be *if* the plant were expanded. (Law and Kelton, 2000)

Simulation is one of the most popular operations research techniques used today. Uses range from evaluating military weapons systems to analyzing manufacturing systems to reengineering business processes (Law and Kelton, 2000). Simulation has become even more widely accepted today because of the advancements in simulation software tools. Software packages, such as Arena, have improved by providing the features needed to help program a simulation model more easily (Law and Kelton, 2000). In the past, complicated simulations took long periods of time to run, making them time consuming and expensive. However, computers today are less expensive and faster, making simulation an even more attractive tool for the operations research analyst (Law and Kelton, 2000).

2.7 Organizational Simulation

"Organizational simulation is the discipline of designing a model of an existing or planned organization, executing the model on a computer, and analyzing the execution output" (Barjis, Dietz, and Groenewegen, 2000). Simulation of an organization allows one to build a model of a system that has many stochastic events (Law and Kelton, 2000). The main impact of organizational simulation is directed at performance analysis, specifically to indicate performance differences between existing systems and the design of future organizational structures (Aguilar, Rautert, and Pater, 1999). Organizational simulation provides decision support and insight into dynamic parameters of the process such as time, volume, and capacities (Aguilar, Rautert, and Pater, 1999).

Organizational simulation can be divided into five subtasks: process description, model design, model execution, model analysis and alternative scenarios evaluation (Barjis, Dietz, and Groenewegen, 2000) as shown in Figure 5.

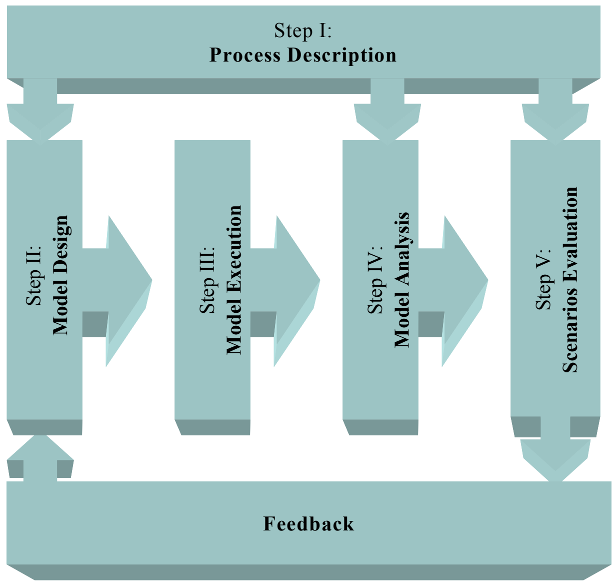

Figure 5. The basic steps in organizational simulation

In the first step, process description, the organization under study is described and the routing order of entities through the system is presented. The second step is considered to be the most critical. When designing the model, it is vitally important to accurately represent the organization in order to properly address the issues at hand. Significant effort must be put into the actual model development in order for the simulation to have predictive capability over the performance measures of the organizational processes. Inaccurate modeling and analysis can lead to poor results and ultimately bad organizational decisions. The third step, called model execution, involves inputting the designed model into a simulation software tool, such as Arena. Models can be designed to give answers at any particular abstraction level; they are only confined by the detail

that is put into their constructs. The fourth step comprises analyzing the organizational model. Arena allows formulation of the simulation output as numerical data to facilitate analysis. Analysis helps pinpoint potential backlogs, inefficiencies, and other related process problems in the current system. In the last step, scenarios evaluation, the analyst builds a conceptual model of the new organizational structure in order to understand the system and answer the questions posed (Barjis, Dietz, and Groenewegen, 2000).

Law and Kelton might have objections to Barjis, Dietz and Groenewegen's five subtasks because there is not one dedicated to Verification & Validation (V&V). "Verification is concerned with determining whether the conceptual simulation model (model assumptions) has been correctly translated into a computer 'program', i.e., debugging the simulation computer program" (Law and Kelton, 2000). "Validation is the process of determining whether a simulation model (as opposed to the computer program) is an accurate representation of the system, *for the particular objectives of the study.*" (Law and Kelton, 2000). In other words, if a simulation is considered "valid", then it is appropriate to use the results of the simulation to make important decisions because it is accurately modeling the actual system. "A simulation model of a complex system can only be an *approximation* to the actual system, no matter how much effort is spent on model building. There is no such thing as absolute model validity" (Law and Kelton, 2000). When developing the simulation model, the analyst should collect high-quality information and data by speaking with subject-matter experts and by observing the actual system in action (Law and Kelton, 2000). Validation is actually an on-going process that requires vigilance on the part of the analyst from the beginning to the end of model development. From validating the data is accurate to analyzing the output from

the finished model, validation ties into all aspects of the modeling process. “Validation is not something to be attempted after the simulation model has already been developed, and only if there is time and money remaining” (Law and Kelton, 2000).

2.8 Summary

This chapter has focused on the processes inherent in the current TA organizational structure as well as those anticipated in the proposed central organization. A brief explanation of the PPBS process and funds execution environment demonstrates how a central system could affect these important functions. The chapter also outlined how other service organizations with similar processes were able to take advantage of a centrally located TA office. An overview of simulation and process design as proven techniques for the business sector was presented. Finally, a discussion on the steps to a successful organizational simulation was reviewed. In Chapter 3, the methodology to tackle a decision on centralization of the TA organizational structure is presented.

3. Methodology

3.1 Chapter Overview

This chapter discusses the simulation methodology used to analyze the best organizational structure for TA related personnel with regards to funds execution. This chapter features the details of Law and Kelton's 10-step process for a sound simulation study (see Figure 6).

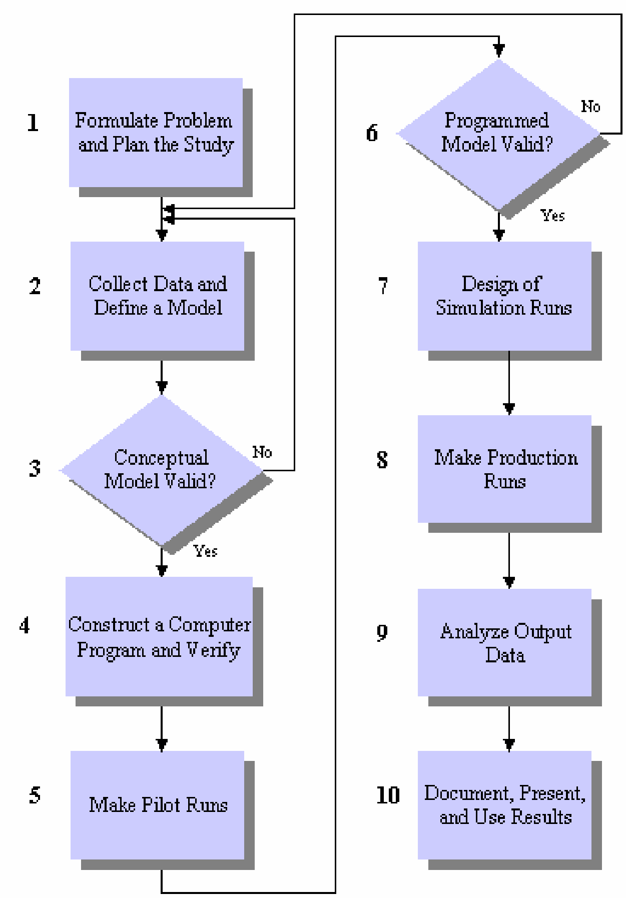

Figure 6. Steps in a simulation study (Law and Kelton, 2000)

The phases involved in Law and Kelton's 10-step process are consistent with that of Barjis, Dietz, and Groenewegen's basic steps in organizational simulation presented in Chapter 2. Law and Kelton's process provides more detail and includes verification and validation.

3.2 Step 1: Formulate the Problem and Plan the Study

The first step involves the development of the problem of interest. One or more meetings with the customer may be required in order to cultivate ideas from the subject-matter experts (SMEs) (Law and Kelton, 2000). The issues shown in Table 1 are developed during this phase:

Table 1. Matters of Importance During Step 1 (Law and Kelton, 2000)

• Overall objectives of the study
• Specific questions to be answered by the study
• Performance measures that will be used to evaluate the efficacy of different system configurations
• Scope of the model
• System configurations to be modeled
• Software to be used
• Time frame for the study and the required resources

3.3 Step 2: Collect Data and Model Definition

The analyst begins collecting information on the system layout and operating procedures during this step. Data collection commences during this phase in order to specify input probability distributions and model parameters. The level of model detail is

important and needs to adequately address the problem of interest. Often the greatest driver in model detail is data availability.

> The level of model detail should be consistent with the type of data available. A model used to design a new manufacturing system will generally be less detailed than one used to fine-tune an existing system, since little or no data will be available for a proposed system. (Law and Kelton, 2000)

Some additional concerns that can affect the level of model detail are performance measures, credibility concerns, computer constraints, opinions of the SMEs, time constraints, and money constraints (Law and Kelton, 2000).

The beginning of an *Assumptions Document* is also an important aspect of this phase. The *Assumptions Document* along with the data leads into the development of the conceptual model. The *Assumptions Document* contains an introduction section that provides important information such as project goals, issues addressed by the model, and performance measures used for evaluation. The document also includes an explanation of any simplifying assumptions that are made during model construction. The *Assumptions Document* helps keep track of information for the inputs to the model. Details about the data, to include sample means and probability distributions that best fit the data set, are incorporated into this document as well (Law and Kelton, 2000).

3.4 Step 3: Conceptual Model Valid?

Law and Kelton suggest performing a structured walk-through of the conceptual model with managers and SMEs. This meeting of the minds can help ensure that the model's assumptions are correct and complete (Law and Kelton, 2000). It can also promote a feeling of ownership, which may strengthen the model's credibility. If the

conceptual model is considered valid, then model progression continues to Step 4. Otherwise, the analyst should return to Step 2 for further evaluation.

3.5 Step 4: Construct a Computer Program and Verify

In this phase of the development of a successful simulation, the model is programmed in a programming language or in a simulation software package (Law and Kelton, 2000). This phase of simulation construction is often considered the most critical step in a successful study. Significant time and effort is required to accurately model the organization of interest (Barjis, Dietz, and Groenewegen, 2000). The design of any simulation model might be easily broken down into two major modeling aspects; the structural modeling and the quantitative modeling. Structural modeling is "the fundamental logic of what you want your model to look like and do" (Kelton, Sadowski and Sadowski, 2002). Quantitative modeling involves researching and integrating the numerical nature of each process, interarrival time, and decide node, among other aspects (Kelton, Sadowski and Sadowski, 2002). Structural modeling is more intuitive, in that the model should attempt to replicate the existing or proposed system. The quantitative modeling aspect is more complicated and therefore will be detailed in the following section.

Quantitative Modeling.

Historical data form input for random variables of interest through the formulation of probability distributions. There are three types of input probability distributions: empirical distributions, theoretical distributions, or trace-driven simulations (Law and Kelton, 2000). A drawback to the empirical distribution and trace-driven simulation is

that the data is bounded by the minimum and maximum values of the historical data. Additionally, the data set may not be large enough to drive a trace-driven simulation (Law and Kelton, 2000).

The use of a theoretical distribution addresses both of these drawbacks. This method involves fitting the data to a theoretical distribution, e.g., exponential or Weibull. A theoretical distribution also has the advantages of less storage space and easier manipulation than empirical distributions or trace-driven simulations. Hypothesis tests are used to determine the goodness of fit. Three commonly used tests are the Chi-Square Test, the Kolmogorov-Smirnov Test, and the Anderson Darling Test. The null hypothesis of all these tests is that the X_i's are IID random variables with the appropriate theoretical distribution (Law and Kelton, 2000). These tests will return a p-value for analysis. If the p-value is greater than the commonly used α-level of 0.05, then the test returns a failure to reject the null hypothesis. This means there is not enough evidence to reject the hypothesis that the sample comes from the theoretical distribution in question. It is important to keep in mind these tests are often not powerful for small sample sizes. In other words, they can be sensitive to small variations between the data and the theoretical distribution. Conversely, if the sample size is very large, the tests almost always reject the null hypothesis (Law and Kelton, 2000).

If there is more than one data set, a test for homogeneity can determine if the data sets can be merged for analysis. The Kruskal-Wallis test assesses homogeneity between *k* independent samples of possibly unequal sizes (Law and Kelton, 2000). The null hypothesis is all the population distribution functions are identical. The *i*th sample of

size n_i is denoted by $X_{i1}, X_{i2}, \ldots, X_{in_i}$ for $i = 1, 2, \ldots, k$ and n denotes the total number of observations, such that:

$$n = \sum_{i=1}^{k} n_i \qquad (1)$$

A rank of 1 is assigned to the smallest of the n observations, a rank of 2 to the second smallest, and so on to the largest value of the set. The next step is to compute the ranks assigned to the ith sample, as follows:

$$R_i = \sum_{j=1}^{n_i} R(X_{ij}) \qquad \text{for i = 1, 2, …, k} \qquad (2)$$

The Kruskal-Wallis test computes a statistic T with the following formula:

$$T = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(n+1) \qquad (3)$$

The null hypothesis is rejected at a level α if $T > \chi^2_{k-1,\, 1-\alpha}$, where $\chi^2_{k-1,\, 1-\alpha}$ comes from the chi-square distribution with k-1 degrees of freedom (Law and Kelton, 2000).

3.6 Steps 5 & 6: Make Pilot Runs and Complete Verification and Validation

Pilot runs are conducted in this phase for verification and validation (V&V) purposes. The simulation analyst and SMEs must review model correctness either through comparisons between the model output and the historical data of an existing system or through "common sense" for a proposed system. Sensitivity analysis is also used to determine if certain parameters or processes are significantly impacting the

simulation model (Law and Kelton, 2000). Kelton, Sadowski, and Sadowski offer insight into sensitivity analysis and its benefits for a simulation model:

> One often-ignored aspect of performing simulation studies is developing an understanding of what's important and what's not. Sensitivity analysis can be used even very early in a project to assess the impact of changes in data on the model results. If you can't easily obtain good data about some aspect of your system, run the model with a range of values to see if the system's performance changes significantly. If it doesn't, you may not need to invest in collecting data and still can have good confidence in your conclusions. (Kelton, Sadowski and Sadowski, 2002)

3.7 Step 7: Design of Simulation Runs

In this stage, it is important to identify the length of each run in the simulation. A run usually consists of simulating any particular duration of time. However, a run could also terminate in a particular event, for example, the event of 1000 entities having been successfully processed through the system. It is imperative to understand the aspect of the system about which the modeling team is trying to gain insight in order to determine the appropriate run length. The constraints of the data may also impact the simulation run length (Law and Kelton, 2000).

This is also the time to determine if a warm-up period is necessary in order to overcome the initial conditions of the system. If a warm-up period is used, the model will reset all the statistics after the warm-up period is complete. This allows the model to overcome the initial biases in the start up of the simulation (Law and Kelton, 2000).

Finally, the number of independent simulation runs using different random numbers is determined. It is not wise to run one replication of a simulation and naively rely upon these results as Law and Kelton point out:

> Since random samples from probability distributions are typically used to drive a simulation model through time, these estimates are just particular realizations of random variables that may have large variances. As a result, these estimates could, in a particular simulation run, differ greatly from the corresponding true characteristics for the model. The net effect is, of course, that there could be a significant probability of making erroneous inferences about the system under study. (Law and Kelton, 2000)

Multiple runs help facilitate the construction of confidence intervals (Law and Kelton, 2000). The construction of confidence intervals and the use of hypothesis tests assume a normality assumption. In order for the normality assumption to be a valid one, there should be at least 30 replications of the simulation (based on the Central Limit Theorem). Departures from normality imply that the actual coverage of the constructed confidence intervals may be lower than anticipated (Law and Kelton, 2000).

3.8 Steps 8 & 9: Make Production Runs and Analyze Output Data

All the necessary production runs are accomplished during Step 8 for verification and validation purposes as well as complete analysis of the output in Step 9. The two major objectives during analysis of the output are: 1) determining the performance of certain system configurations, and 2) comparing alternative system configurations (Law and Kelton, 2000). This analysis is accomplished through the use of output statistics, hypothesis tests, and confidence intervals.

3.9 Step 10: Document, Present, and Use Results

During this phase, it is important to document the work completed in order that future work can expand on the work already accomplished. Documentation should include all assumptions, the computer program, and the study's results (Law and Kelton,

2000). The results are presented to the customer in this final stage of the simulation process. Use of animation can help communicate the model to managers and endusers who may not be familiar with all the details of the model (Law and Kelton, 2000). The presentation should include insight into the model development as well as the model validation process. This helps build model credibility with the customer. Ideally, the customer will take action based on the results of the modeling effort.

4. Model Building and Output Analysis

4.1 Chapter Overview

The work presented in this chapter uses the structure of Law and Kelton's 10-step process to describe the construction and subsequent analysis of the simulation models developed in this research. A discussion on the techniques and methods used in the verification and validation stage of this simulation effort is also presented. A segment of this chapter is devoted to analyzing the output from these two simulation models; specifically, comparisons between the two systems and analysis of the proposed central architecture.

4.2 Formulation of the Problem and Planning the Study (Step 1)

In conjunction with Step 1 of Law and Kelton's 10-Step Process, meetings were conducted with the customer (AF/DPLE) to gain insight into the necessary elements for model development. The objective of this study is to determine if a central system will gain efficiencies in manpower or produce any cost savings. This simulation is meant to answer the thesis question in terms of a manpower usage statistic; in the simulation model, this is a manpower utilization per entity through the system. The complete processing time in system gives us a "manpower used per entity" performance measure, where each entity is an actual TA application. Another expectation of the central model is to provide information on the number of people required to man a central office. AF/DPLE proposed manpower objectives for a central office in their submitted Staff Summary Sheet. The simulation can either validate their proposal or provide new insight

into the manpower required. The simulation is focused on the funds execution aspect of the TA organization. Centralization with regard to the PPBS process is analyzed separately and is outside the scope of the simulation model. The simulation software package used for the modeling effort is Arena by Rockwell Software. Arena is a Microsoft® Windows® application and is fully compatible with other Windows® software.

4.3 Data Collection and Model Definition (Step 2)

An understanding of how the current system functions came in the form of onsite visits to Base Education and Training Flights and from personal interviews with Base Education and Training Flight personnel. A conceptual understanding of the proposed central system came from discussions with the customer as well as from documentation provided in the form of a Staff Summary Sheet submitted by AF/DPLE on 22 October 2001. The data for this research originates from the Air Force Automated Education Management System (AFAEMS) and a sign-in tool utilized by the Air Combat Command (ACC). AFAEMS is a robust software program that allows the collection of data pertaining to nearly every aspect of TA. The ACC sign-in tool tracks the time individuals enter the Base Education and Training Flight, the time service begins, and the time service is complete for various activities. This tool is currently limited to ACC.

Despite indications from AF/DPLE that the TA application process may be cyclical, it is impossible to model the entire calendar year due to data constraints (further discussion on this subject is found in Section 4.5). Therefore, in meetings with AF/DPLE, the model building team determined the development of a model representing the months of June, July, and August should adequately capture a typical range of months

in the TA cycle. Due to the modeling techniques used in the current system model, it is necessary to warm-up the simulation over a period of months to ensure the appropriate distribution of invoices and grades arriving. This constraint directed the modeling effort months later in the year.

Alternative designs of the central system may involve altering our assumptions about how this process will work, as long as the assumptions remain in the range of realistic and feasible options. Modeling the appropriate mix of assumptions will lead to the best organizational structure for the central system.

4.4 Validity of Conceptual Model (Step 3)

Step Three in Law and Kelton's 10-Step Process is in place to ensure the modeling team checks the conceptual model before progression to the model development phase. Through meetings with AF/DPLE on separate occasions, it was determined the conceptual model was accurately modeling the level of detail necessary to answer the questions of this study. This was accomplished by means of a structured walk-through of all the major modeling concepts.

4.5 Construct a Computer Program and Verify (Step 4)

This section discusses in detail the data analysis, modeling assumptions, and resulting inputs that comprise the two models being developed for this thesis effort. This section first describes the modeling efforts required to accurately capture the TA application arrivals. Second, an explanation of details involved with modeling the major processes in the model is presented. Finally, the data analysis with regards to the logic

behind the decide modules is detailed. These steps are elaborated for each of the two models.

Model of the Current System.

The model presented in this section simulates the current TA execution environment. This model focuses on one typical base because it is impractical to model each of the 82 Base Education and Training Flights in the Air Force. The output of this model is compared with the output from the model for the proposed central system. As discussed in the previous sections, the data derives from the AFAEMS database and the ACC sign-in tool. However, additional information was solicited from subject matter experts where no data was available.

TA Application Arrivals.

The arrival rate of TA applications is a major factor in the simulation model; therefore, careful analysis of the data available for this particular node is essential. First, it is important to understand the condition of the data. The AFAEMS database is still in its infancy and only goes back as far as 2000. The data available is most accurate and complete for the 2002 calendar year, as illustrated in Table 2:

Table 2. Data Entries per Calendar Year

Calendar Year	Number of Entries
2000	31
2001	57,297
2002 (Jan – Sep)	171,941

The 2002 data is used for the model development based on its completeness and accuracy.

Two sources of information are available with respect to arrival of TA applications, AFAEMS and the ACC sign-in tool. AFAEMS provides an issue date for each individual TA application and the ACC sign-in tool records the time each person comes into a Base Education and Training Flight to seek TA. The Base Education and Training Flights indicated there were definitely periods throughout the year that were busier than others (Base Education and Training Flights and MAJCOM Representatives, 2002). This appears logical due to the inherent cyclical nature of school schedules and registration periods. To verify this claim and to better understand how to model this cyclical nature, a plot of the number of TA applications per day over the period between 1 January 2002 and 30 September 2002 was prepared for the typical base in question (see Figure 7).

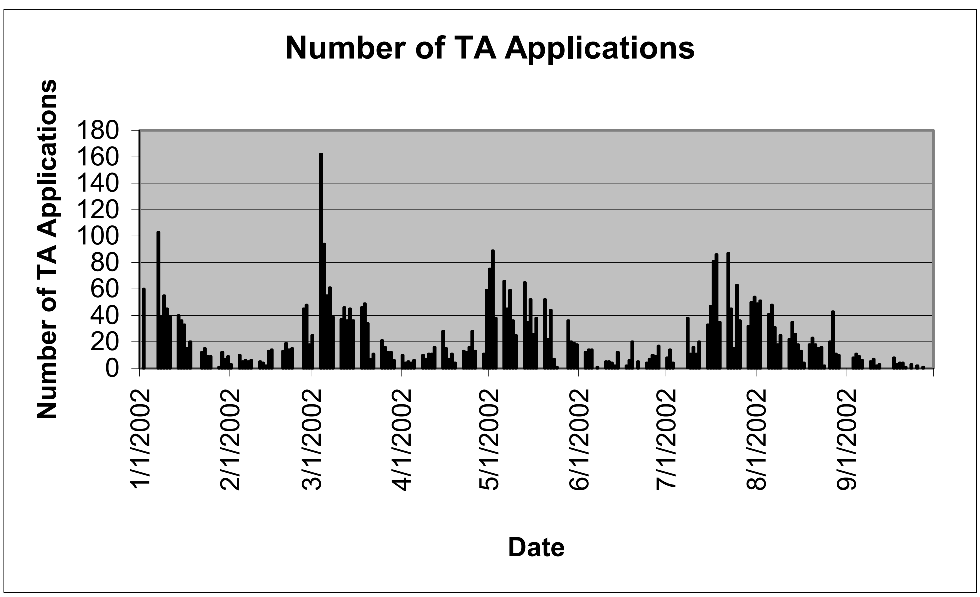

Figure 7. Number of TA Applications (January through September)

Clearly, the data shows that the arrival of TA applications is truly cyclical. It is still necessary to determine if this base is typical of the rest of the bases in the Air Force. In

order to lend credence to this hypothesis, a similar plot was created for the entire Air Force, to determine if the pattern is analogous (see Figure 8).

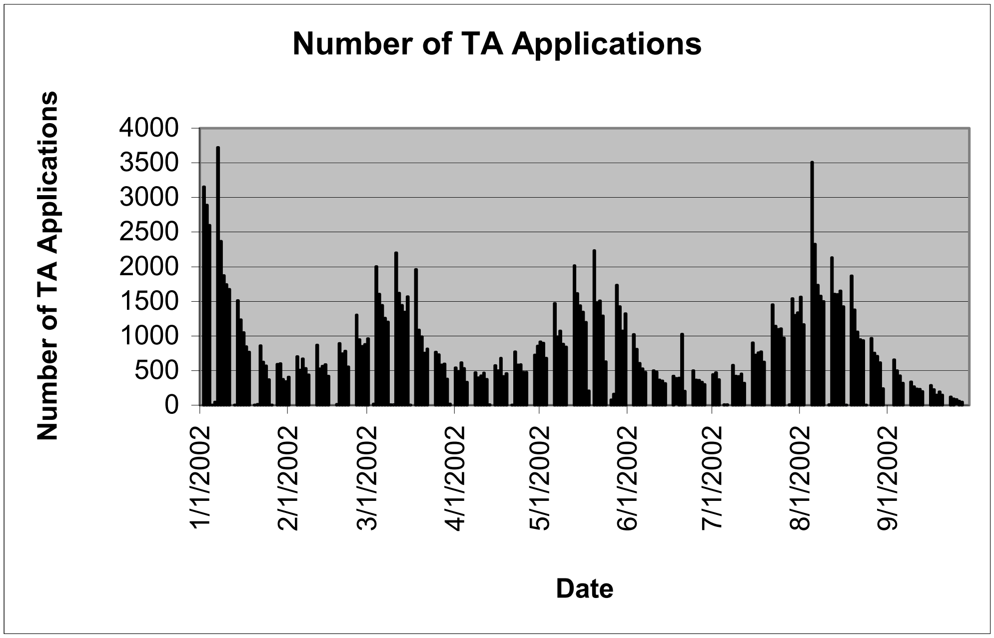

Figure 8. Number of TA Applications for the AF (January through September)

As the figure reflects, the cyclical pattern is comparable to the one found in the plot for the typical base.

A schedule of arrivals is required to accurately model the system over a period of months. Arrivals of potential TA applicants happen between the hours of operation at the Base Education and Training Flights. The model development team determined a typical day consisted of 8 hours. Each day of the simulation period is modeled with TA applicants arriving for 8 hours of the day, 5 days of the week (excluding holidays), for the months of January through August. Arena requires inputs to be recorded in an arrival per hour manner when using the schedule module. The ACC sign-in tool provided excellent exponential interarrival times (the time in minutes between the *i*th and the (*i*+1)th customer). The mean of these interarrival times are easily transformed into Poisson

arrival rates by taking the inverse and multiplying this value by 60. The Poisson distribution is used to capture the stochastic nature of the TA application arrival rate because of some of its important properties. A stochastic arrival process is said to be a Poisson process if: 1) the customers arrive one at a time, 2) the number of arrivals in a particular time interval is independent of the number of arrivals in an earlier time interval and independent of the time the arrivals occur, and 3) the distribution of arrivals in a certain time period is independent of time itself (Law and Kelton, 2000). With the intention of validating the data provided by the ACC sign-in tool, we looked at the AFAEMS data. When comparing the two databases, it was evident there were conflicting results (see Table 3)

Table 3. 2002 Data for the Poisson Arrival Rates for a typical base

	From AFAEMS data			From ACC Sign-in Tool			
	Avg per Day	Avg per Hour	Number per Month	Mean Interarrival Time	Inverse	x60	Number per Month
January	26.6190	2.9577	559	30.3	0.0330	1.9802	154
February	13.6111	1.5123	245	39.9	0.0251	1.5038	152
March	40.4762	4.4974	850	14.0	0.0714	4.2857	634
April	13.6818	1.5202	301	32.7	0.0306	1.8349	235
May	39.4545	4.3838	868	10.7	0.0935	5.6075	594
June	7.45000	0.8278	149	35.7	0.0280	1.6807	207
July	37.4286	4.1587	786	13.7	0.0730	4.3796	625
August	26.2381	2.9153	557	17.3	0.0578	3.4682	509
September	3.80000	0.4222	77	41.1	0.0243	1.4599	95

The ACC sign-in tool and the AFAEMS database do not match for several reasons. This is due in part to the fact that the ACC sign-in tool tracks applicants while the AFAEMS database tracks applications. Two examples of how these differences affect the databases follows. First, more people may arrive at the Base Education and Training Flights to apply for TA than actually receive TA. This results in the ACC sign-

in tool having a greater number of applicants. Second, students using the ACC sign-in tool and being issued TA for more than one class, results in the AFAEMS database showing a greater number. The data is not expected to differ greatly despite these subtle differences. The differences reflected in the data shown in Table 3 are fairly significant. Due to the infancy of the ACC sign-in tool and through discussion with SMEs, it was determined that the AFAEMS data is a more accurate assessment of the arrival rate of TA applications. The AFAEMS average per hour column from Table 3 is utilized in the formulation of the arrival rate for TA applications. A separate Poisson distribution is used to model the varying arrival rates for each month.

Description of the TA Processes.

Even though there is reason to doubt the completeness of the data from the ACC sign-in tool for interarrival times, there is no reason to suspect the TA service times. The service times are independently gathered from those arriving at the Base Education and Training Flights based on a beginning service time and an ending service time. The IID assumption was validated using a time series autocorrelation plot. The Input Analyzer software tool assisted in analyzing the data from the typical base. Input Analyzer is a software program that comes with the Arena software package, and it is specifically designed to analyze the distribution of a data set. Twenty-five percent of the data was randomly selected to analyze through Input Analyzer. The entire data set was not utilized because there were too many data points to receive a good reading from any of the standard statistical goodness-of-fit tests. Input Analyzer fitted the distribution seen in Figure 9 to the data.

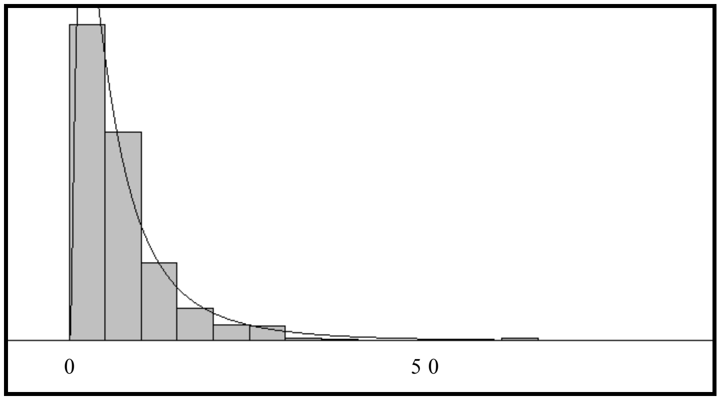

Figure 9. TA Service Times Distribution (in minutes)

Input Analyzer indicated a 1+Lognormal(8.59, 10.7) distribution (in minutes) for the processing of a TA application. The Kolmogorov-Smirnov Goodness-of-fit Test returned a p-value of 0.0568, which is greater than the study's α-level of 0.05. This indicates the lognormal distribution is an adequate fit to the data.

The lognormal distribution is often utilized to model the time to perform some task and is therefore an excellent distribution for TA service times. The parameters in the parenthesis indicate the mean, μ, and standard deviation, σ, respectively. The distribution's range is [0, ∞). The parameter μ is the scale parameter and σ is the shape parameter of the distribution (Law and Kelton, 2000).

If a student is required to reimburse the government for failing to satisfactorily complete a course, the student goes to the Base Education and Training Flight for the processing of a reimbursement. The ACC sign-in tool supplied the necessary data to analyze a distribution for this process. The data satisfied the IID assumption. The distribution Input Analyzer fitted is illustrated in Figure 10.

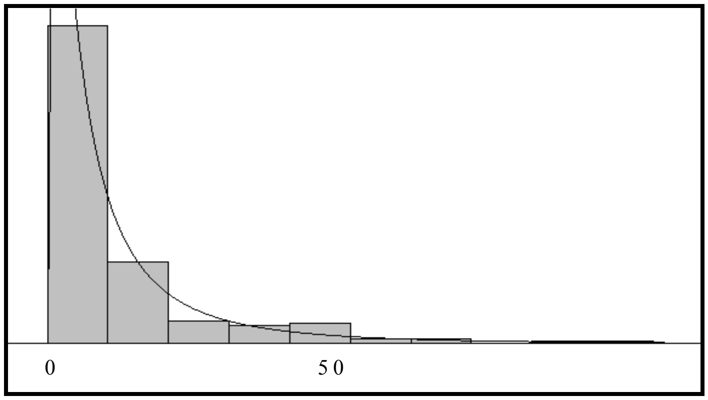

Figure 10. Time to Process a Reimbursement Distribution (in minutes)

Input Analyzer indicated a reimbursement processing time of 1+Lognormal(14.5, 26.8) in minutes. The Kolmogorov-Smirnov Goodness-of-fit test returned a p-value of greater than 0.15, indicating that the Lognormal distribution is a valid fit to the data.

There is no data available for the remaining processes in the model of the current TA execution environment. Valid distributions for these processes were determined through consultation with SMEs. The Triangular Distribution is a distribution with nice properties for situations when data is not available. The Triangular Distribution requires that a minimum value, a most likely value, and a maximum value be specified in the following manner: Triangular(minimum value, most likely value, maximum value). After numerous consultations with the SMEs, the following distributions were determined appropriate for the remaining processes (see Table 4):

Table 4. Distributions for major TA Processes (in minutes)

Process	Distribution
Verification of a Passing Grade	Triangular(.15, .5, 5)
Generate AF Form 118 Forms	Triangular(3, 5, 10)
Processing Waiver	Triangular(3, 5, 10)
Verification of Invoice	Triangular(.42, .5, 5)
Processing GPC Statement	Triangular(.42, .5, 10)

As an example, the Triangular(3, 5, 10) distribution for processing a waiver was generated by Input Analyzer using 5000 data points and is illustrated in Figure 11.

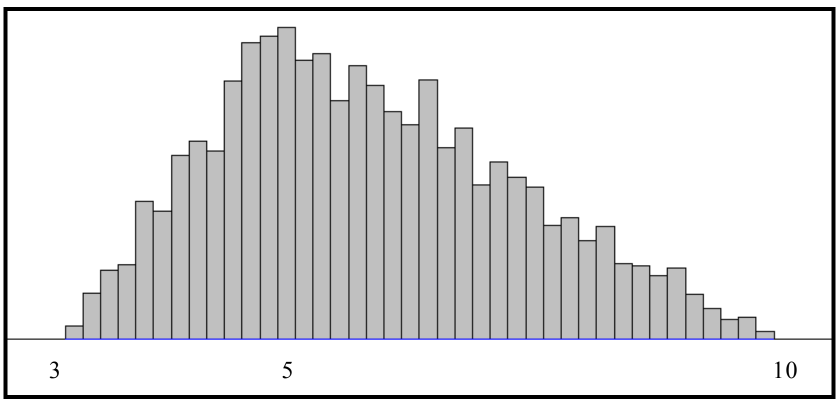

Figure 11. Triangular(3, 5, 10) Distribution for processing a waiver

In addition to the major processes, there are two delay nodes in the model. The first delay node models the duration of time between issuance of TA and the arrival of the course grade. Through the AFAEMS database, dates were provided for the day TA is issued and the beginning and ending dates of the course in which the student is enrolled. The actual day a grade is received is not recorded in AFAEMS. A good approximation to this date is the course end date because a grade normally follows shortly after this date. The data set with the following distribution was produced using the duration of time between the TA issue date and the course end date (see Figure 12).

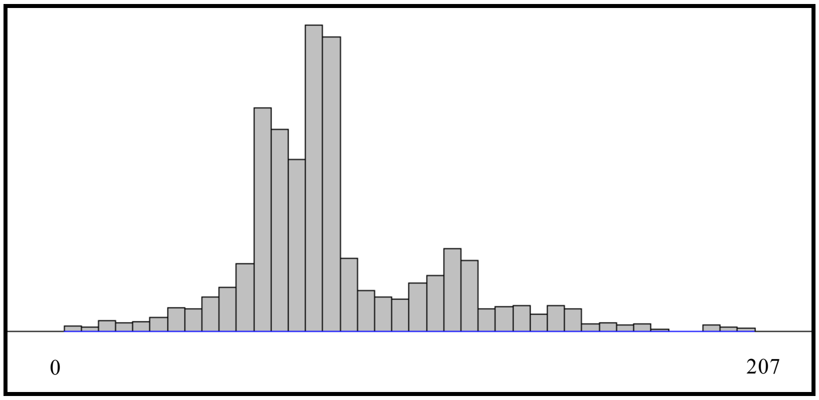

Figure 12. Delay for Grades Distribution (in days)

The data appears to be multimodal as might be expected. This is a result of students taking courses from a variety of institutions with varying term lengths (e.g. quarter, semesters, etc.). There is no way to determine which courses are coming from which distribution and there is no theoretical distribution that will fit this data. Therefore, a uniform distribution was set up between the likely minimum and maximum values in the range of delay times for grade receipt. A Uniform(50, 110) distribution in days is being used for the input to this module. This is based on the sample standard deviation spread about the sample mean.

Law and Kelton indicate that the Uniform distribution is "used as a 'first' model for a quantity that is felt to be randomly varying between *a* and *b* but about which little else is known" (Law and Kelton, 2000). The Uniform distribution adequately brings the level of detail necessary to model this delay module. Trying to build more modeling detail into a distribution in which little is known could end up over-biasing the model.

The second delay node involves the time it takes to receive an invoice from the school. This duration of time came from AFAEMS and is based on the time difference

between the TA issue date and the invoice arrival date. The data tends to be multimodal based on the same rationale given above (see Figure 13).

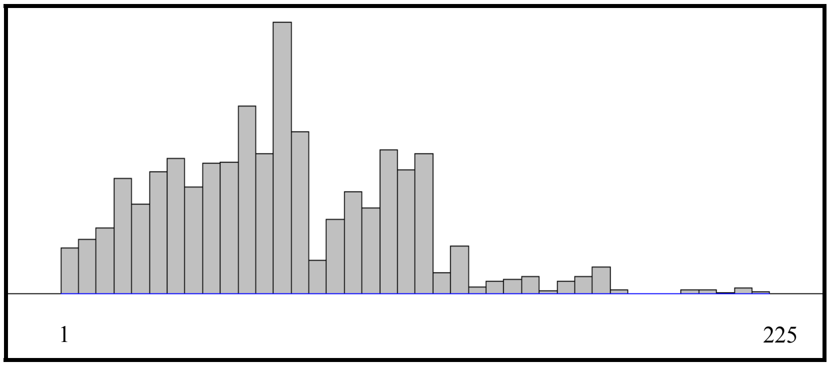

Figure 13. Distribution for the Invoice Delay Time (in days)

It is impossible to differentiate the data in order to analyze them separately; therefore, a Uniform(30, 110) distribution, modeled in days, was determined the best suited distribution for the data available. This is based on the sample standard deviation spread about the sample mean. The Uniform distribution was chosen for the same reasons noted above. Note that it might seem odd an invoice may arrive before the grade is received; however, this is not atypical in the existing TA environment. Schools often invoice when the last day to drop classes without penalty has passed. This school billing procedure makes it very viable for a Base Education and Training Flight to receive an invoice before the student completes a course. In addition, the distribution for the delay for a grade and the delay for an invoice can and do overlap. Therefore, these delays cannot be modeled in sequence. To account for this complication, a duplicate module is used to make a copy of the TA application entities. This modeling technique enables the simulation to be more robust.

Decide Module Logic.

Other important aspects of the current TA execution model involve the decide node logic. The first decide node determines the proportion of students issued TA that do not satisfactorily complete their course. Of the 4403 records for the typical base in 2002, AFAEMS is registering 2425 records with grades recorded. Of the 2425 records with grades registered, 175 did not satisfactorily complete the course. Table 5 illustrates the distribution of these grades.

Table 5. Grade Distribution for the typical base

Grade	Number of Records
Failure	41
Incomplete	56
Withdrawal	76
Unsatisfactory	2
Total	**175**

Dividing 175 by the 2425 records gives a percentage of 7.216% for those not satisfying the course requirements.

Of those students that are required to reimburse the government for not satisfying the requirements of their course, a certain percentage are eligible for a waiver. However, based on the data in AFAEMS, as well as speculation by AF/DPLE, those eligible for waivers and those actually receiving waivers are not always a one-to-one correspondence. Therefore, to accurately model the current system, we look at the percentage of those students actually receiving waivers. Twenty-eight waivers were issued to the 175 students that did not successfully complete their course, so 16% received waivers.

The final decide module determines the percentage of students that actually reimburse the government. Sixty-Six of the remaining 147 students completed the

reimbursement transaction. This signifies that only approximately 44.90% of the students are indeed reimbursing the government. All of the logic and distribution information presented in this section formed the current simulation model, which is illustrated in Figure 14.

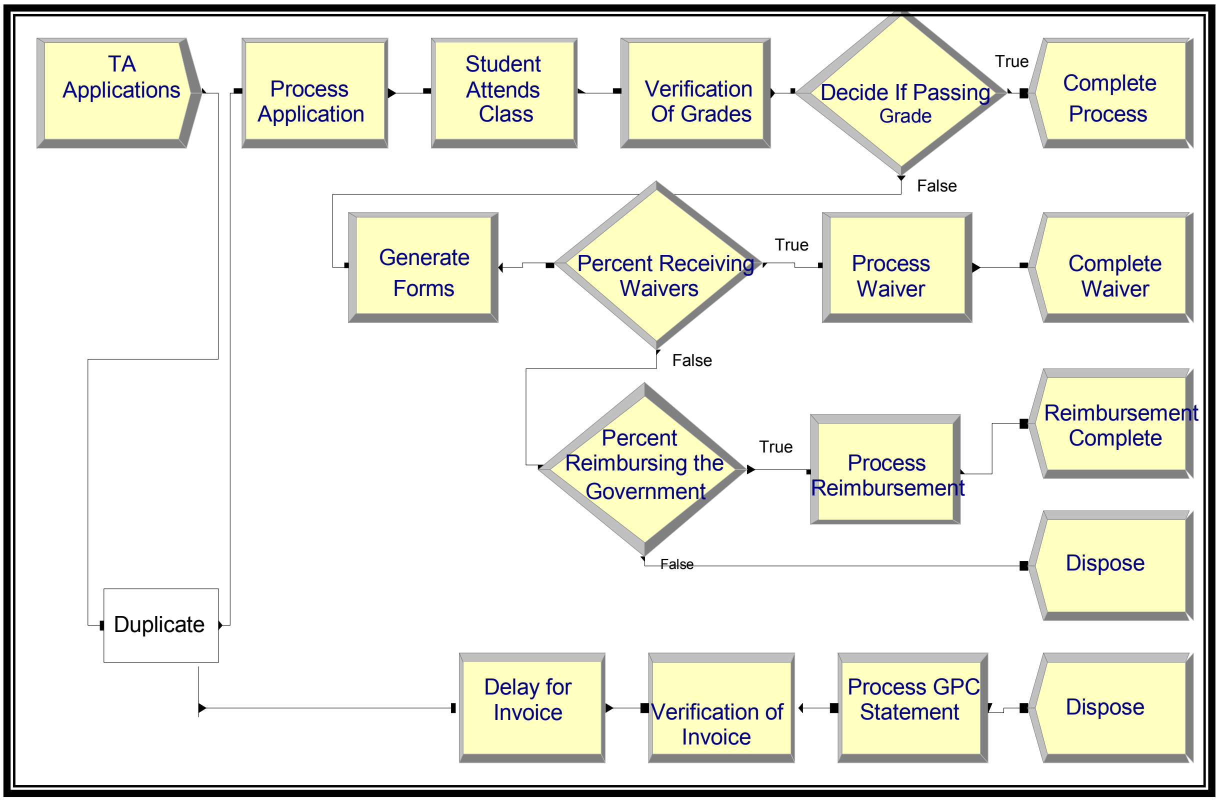

Figure 14. Model of the Current TA Execution Environment

Model of the Proposed Central System.

A discussion on the modeling of the proposed central TA execution environment is now presented. This model focuses on the processes that are different in the central system. The 2002 data from AFAEMS that encompasses the entire Air Force drives this model. No data is available for processes not currently in place; therefore, SMEs were consulted for the formulation of input probability distributions.

TA Application Arrivals.

The arrival of TA applications to a central office is equivalent to the arrival rate across the Air Force. The arrivals were modeled in a similar manner to the arrivals for the current TA system (they encompass analogous properties, e.g., a cyclical arrival rate). A schedule was also set up for the arrival of the TA applications to mimic the hours of operation for the Base Education and Training Flights. The arrival schedule for the central system is illustrated in Table 6.

Table 6. 2002 Data for the Poisson Arrival Rates for the Central System

	From AFAEMS data		
	Avg per day	**Avg per hour**	**# per month**
January	1417.0476	157.4497	29838
February	693.7368	77.0819	13195
March	1205.2857	133.9206	25369
April	534.1818	59.3535	11764
May	1275.0455	141.6717	28503
June	487.5000	54.1667	9753
July	819.4762	91.0529	17235
August	1420.4091	157.8232	31267

The values in the average per hour column of Table 6 are used in the construction of the arrival rates by utilization of the Poisson distribution. In the current model, the TA applications were able to drive the entire simulation by use of hold modules that simulated the time it would take to receive a grade and an invoice. This was the intent of the central model as well; however, despite the deployment of the industrial version of Arena, the model could not hold enough entities in the system to run the length of the simulation. Arena allows up to about 80,000 entities in the system at one time. The data being used to drive this simulation exceeded this array size. In order to work around this problem, separate arrivals for grades and invoices were developed.

The same methodology was utilized to model the arrival of grades. AFAEMS supplied the required course completion dates. The assumption here is the course completion date will match up with the approximate time a grade is received by the base office. The AFAEMS database provided the following information (see Table 7).

Table 7. 2002 Data for the Poisson Grade Arrival Rates for the Central Model

	From AFAEMS data		
	Avg per day	**Avg per hour**	**# per month**
January	97.6333	15.1874	2929
February	330.0000	51.3333	9240
March	899.5484	139.928	27886
April	307.8000	47.8800	9234
May	1519.0968	236.304	47092
June	292.3667	45.4793	8771
July	733.0968	114.037	22726
August	607.6129	94.5176	18836

The values in the average per hour column serve as the input parameter λ for the rate of the Poisson distribution. The invoice arrivals required a similar type of modeling due to the size of this simulation. The invoice arrival rate is calculated using the invoice date in the AFAEMS database. The analysis performed on the TA arrival rate and the grade arrival rate is duplicated for the invoice arrivals (see Table 8).

Table 8. 2002 Data for the Poisson Invoice Arrival Rates for the Central Model

	From AFAEMS data		
	Avg per day	**Avg per hour**	**# per month**
January	572.4762	63.6085	12022
February	983.3684	109.2632	18684
March	775.0476	86.1164	16276
April	1023.2273	113.6919	22511
May	677.1818	75.2424	14898
June	800.7500	88.9722	16015
July	912.3333	101.3704	19159
August	590.2727	65.5859	12986
September	880.52381	97.8360	18491

Similarly, the average per hour values are used as inputs for the Poisson distribution within the simulation.

Description of TA Processes Under Centralization.

Since the central system is not in existence at the present time, most of the processes involved in the centralized version of the TA execution environment require an educated estimate on the part of the SMEs to formulate distributions. There is one process that remains virtually the same under centralization, despite the action occurring at the central office instead of at the separate Base Education and Training Flights. This action is the processing of a reimbursement. The data used for this process in the current model utilized the data from the *typical* Base Education and Training Flight. The ACC sign-in tool provides access to data sets from five different bases. The analysis involved conducting a Kruskal-Wallis test for homogeneity to determine if these data sets are homogeneous and can therefore be merged. The test failed with all five bases included in the analysis with a T statistic of 63.47 and a $\chi^2_{k-1,\,1-\alpha} = 9.488$. However, upon further inspection, it was found that one of the base's average reimbursement processing time is significantly smaller than the rest of the samples. The test was recomputed with this outlier omitted. The test failed to reject the null hypothesis with a T statistic of –25.71 and a $\chi^2_{k-1,\,1-\alpha} = 7.815$. Therefore, we combined the data for these four bases in order to develop a distribution for the reimbursement process. The data satisfied the IID assumption by indication of a time series autocorrelation plot. The data formed the following distribution (see Figure 15).

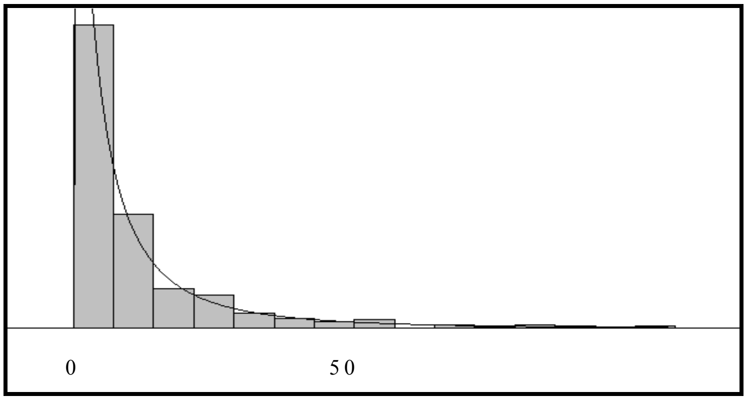

Figure 15. Distribution for Reimbursement Process (in minutes)

Analysis in Input Analyzer revealed a 1+Lognormal(14.4, 32.8) distribution for this data set. The Kolmogorov-Smirnov test gave a p-value of 0.0902 which is greater than the α-level of 0.05. Additionally, a Chi-Square test revealed a p-value of 0.409, adding credence to the chosen distribution. These tests indicate the chosen distribution is an excellent fit to the data.

The remaining processes in the central model required the expertise of the SMEs in order to formulate distributions. The following table depicts the different processes and the corresponding distributions formulated by a group consensus of the SMEs.

Table 9. Distributions for major TA processes under centralization (in minutes)

Process	Distribution
Counselor Reviews Application	Triangular(.5, 5, 15)
Grade Verification	Triangular(.33, .5, 5)
Processing Waiver	Triangular(3, 5, 10)
Verification of Invoice	Triangular(.42, .5, 5)
Processing GPC Statement	Triangular(.42, .5, 10)

Decide Module Logic.

The first decide module involves determining the percentage of students that do not satisfactorily complete their course requirements. A consultation of the 2002 AFAEMS database yielded the results shown in Table 10.

Table 10. Grade Distributions for the Air Force

Grade Description	Observations
Total Observations	130,259
Withdrawals	6,857
Unsatisfactory	95
Incomplete	2,631
Failure	2,371
D (graduate school)	15
Total Failing to Successfully Pass Course	**11,969**

Dividing this total by the total observations during this period indicates a 9.189% rate of students failing to successfully pass their course. The other decide module involves determining if a student is eligible for a waiver given they have not successfully passed their course. Table 11 illustrates the distribution of waived reimbursements based on the reimbursement reason. This information was gathered from all Air Force entries for the year 2002.

Table 11. Distribution of Waived Reimbursements

Reimbursement Reason	Observed	Waived
PCS	122	94
TDY	744	669
Emergency Leave	76	73
Hospital Stay	184	180
Duty Change	581	530
Failure	897	33
Separation	91	38
Personal	4378	147
Other	202	96
Not Applicable	293	21
Incomplete	40	4
No Reason Indicated	4345	42
Subtotal	11953	1927
D (graduate school)	14	1
Total	**11967**	**1928**

Dividing 1928 by 11,967 (16.11%) yields the actual percentage waived. For the central system, it is more prudent to find a percentage of those students eligible for waivers, since a desirable characteristic of the central system is it will be more rigid in the assessment of waiver eligibility. Taking away the personal touch may result in fewer waivers authorized for circumstances not falling under the AFI approved reasons. This concept proved true for the Navy and Marines and is expected if the Air Force centralizes their operations. There are 1707 entries, out of the 11,967, designated as an AFI approved reason in AFAEMS. This results in a percentage of 14.262% for those students eligible for a waiver. This is the percentage used in the model. This completes the analysis of the inputs for the central model. A simplified version of the main processes, decide modules, and arrival and disposal nodes is illustrated in Figure 16.

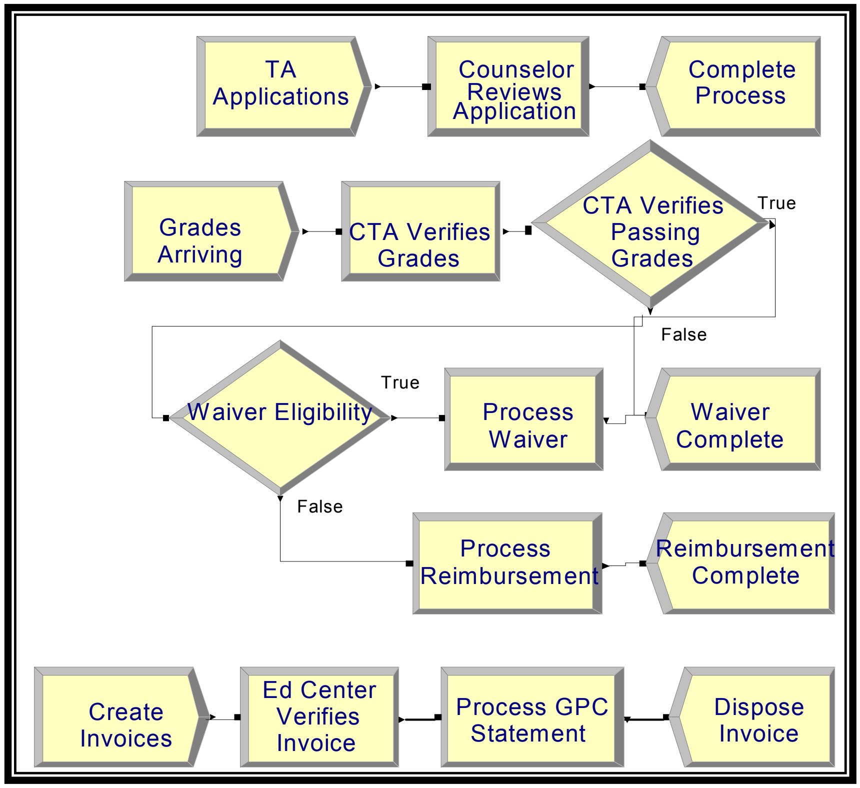

Figure 16. Simulation Model of the Central TA Execution Environment

4.6 Make Pilot Runs and Complete Verification and Validation (Step 5 & 6)

Thirty replications of each system were completed for verification and validation (V&V) purposes. With just minor modifications to the current system, the model ran smoothly and in the desired manner. Verification for the central system proved to be a little more complicated. The biggest problem (exceeding Arena's entity array size) and the resultant resolution is described in the previous section. Initiating the entire model with the TA arrivals across the Air Force and attempting to hold the entities for grades and invoices at a later date, created a situation where too many entities were in the system at one time. In order to make the model run appropriately, separate arrival modules were set up for grades and invoices. After this adjustment, the model progressed in the desired manner.

In order to verify and validate the output of the current system, thirty replications were run in order to facilitate the creation of confidence intervals. These 95% confidence intervals are compared with historical data to validate the output of the system. Table 12 shows the current simulation model's 95% confidence intervals and the typical base's corresponding historical figures for the number of TA applications, reimbursements, and waivers for the month of August 2002.

Table 12. Verification and Validation for the Current Simulation Model

	TA Applications	Reimbursements	Waivers
Simulation	(464.43, 655.84)	(13.476, 19.124)	(4.9662, 7.1671)
AFAEMS	557	9	6

The AFAEMS data in the table above represents a single replication of the actual current TA system. Therefore, it is not imperative these values fall in the middle of the confidence interval range as one might expect if the value was an average; however, they should have a close association. It appears the simulation is reasonably accurate in modeling the number of TA applications and the number of waivers. There is a concern for the simulation output for the number of reimbursements since the AFAEMS data does not fall relatively close to the bounds of the confidence interval. Of the thirty replications used to calculate the confidence intervals above, six replications indicated nine or less reimbursements. This reinforces that under the assumptions of this simulation, nine reimbursements in the month of August is a reasonable value. Furthermore, in response to this situation, additional analysis of the average reimbursement rate across the Air Force was conducted with virtually the same results. This is an excellent indication that

the nine reimbursements from the historical data is a feasible outcome from this simulation.

The central model simulated the thirty replications necessary for the construction of confidence intervals. Table 13 shows the output in the form of 95% confidence intervals and the corresponding AFAEMS historical data for the month of August 2002 across the Air Force.

Table 13. V&V Results for the Central Model

	TA Applications	Grades	Failing Grades	Invoices
Simulation	(30,576, 31,930)	(17,631, 19,263)	(1615.7, 1768.2)	(12,238, 13,424)
AFAEMS	31267	18836	1605	12986

Different output statistics are used for the verification and validation efforts for this model because it is important to determine if the number of grades and invoices are being generated correctly. In addition, it is not imperative to know the number of reimbursements and waivers because the assumptions in the central model are different and are not expected to correlate closely to the historical data. Every output from the simulation correlates closely with the historical data except for the failing grades. It appears the simulation may be generating too many failing grades. Recall the historical value signifies one replication in time and not the average, so it is not expected that this value hit the middle range of the confidence interval. Upon further inspection of the replications used to calculate the confidence interval for the failing grades, 15 of the 30 replications indicate a number of failing grades at or below the historical value of 1605. Based on the above, the simulation is producing a reasonable number of failing grades when compared to the historical value. Therefore, the simulation is producing valid output results when taken in the historical context.

4.7 Design of Simulation Runs (Step 7)

Both models have a warm-up period of five months to overcome the initial conditions of the system, allowing for the capture of statistics for the months of June, July, and August. This is due to the design of the current TA model. There are delay modules in the current model that mock the time to receive a grade and an invoice from each TA application. In reality, a TA application issued in February might not invoice until August. It is this type of situation the model is capturing through the use of a warm-up period. This warm-up period allows the appropriate distribution of applications, invoices, and GPC statements for the months of interest.

A standard 30 replications is utilized in order to analyze the output with standard hypothesis tests and through the use of confidence intervals.

4.8 Make Production Runs and Analyze Output Data (Steps 8 & 9)

The production runs in the form of 30 replications for both models generate the necessary data for the resultant output analysis. AF/DPLE is particularly interested in potential savings in dollars and manpower, as well as gains in efficiency, accuracy, and consistency (AF/DPLE, 2002). The performance measure to tackle the question of savings in manpower is a manpower utilization per entity statistic, as discussed in previous sections. Gathering this statistic over 30 replications of the two systems assisted in the formulation of 95% confidence intervals (CIs). Three months of output are displayed in Table 14 to determine if variation exists between the months. Table 14 illustrates the resultant confidence intervals for the months of June, July, and August.

Table 14. Manpower Utilization per Entity Through the System (CIs in minutes)

	June	July	August
Current	(18.110, 18.467)	(17.933, 18.365)	(17.975, 18.288)
Centralized	(13.090, 13.191)	(13.752, 13.999)	(15.123, 15.629)

The confidence intervals for this performance measure tend to have a very small width. These confidence intervals are constructed from the average time in system over the 30 replications. Within each replication, thousands of entities move through the system to determine the average value for that replication. Due to the rather large amount of entities that flow through the system, the average value for each replication tends to hone in on a value very close to the true average of the system. It is also logical the central system's confidence intervals are tighter than the current system because the central model has a larger number of entities flowing through the system.

The confidence intervals in Table 14 show a savings in manpower utilization. It is important to determine the magnitude this savings has on potential manpower requirements at the base level. In order to do this, the average time for each process was multiplied by the number of entities for that particular month and then divided by 60 minutes per hour. All these values are totaled for each replication. This statistic gives the expected number of manhours within each month saved at the base level through centralization. This is an indication of what kind of savings the base level offices might expect if the functions discussed are relocated to a central office. Converting this output to an actual manpower savings by dividing this statistic by 160 working hours per month, gives an actual manpower savings statistic (or the number of workers saved at the local base offices if centralization takes place). Table 15 illustrates the confidence intervals for the months of June through August.

Table 15. CIs for Manpower Savings at the base level (measured in people)

	June	July	August
Manpower Savings	(21.755, 22.112)	(34.995, 35.921)	(42.944, 44.886)

Table 15 demonstrates the savings expected at the local base level through centralization. The total manpower savings is addressed later in this section, after the analysis on the number of individuals necessary to man a central office is presented. The months of June through August are utilized for this analysis in order to obtain a range of output for this statistic. The analysis is limited to these months based on data constraints, as previously discussed. The simulation for the current system must warm up for at least 4 months in order to provide the correct distribution of grades and invoices and the data is only available between the months of January through August. Table 15 indicates a large distribution in manpower savings over this period of 3 months. This is due to the large variation in the number of applications, grades, and invoices that arrive during the months in the analysis (Table 16).

Table 16. Number of Applications, Grades, and Invoices

	June	July	August
Applications	9,753	17,228	31,267
Grades	8,771	22,726	18,836
Invoices	16,020	19,154	12,896

Table 15 indicates a savings of at least 21 people at the base level under centralization. In some months, when the volume of work is much greater, the savings are likely to be twice this amount.

The next area of analysis involved a validation of AF/DPLE's proposed central system configuration. In the Staff Summary Sheet submitted on 22 October 2001,

AF/DPLE estimated a total of 12 people are required to administer a central office. The simulation created to evaluate the central system provides insight in determining if this is a valid number of workers to effectively man a central office. The best indication of adequate manpower is to look at the average time in queue an entity waits to be serviced. An adjustment in the number of workers drastically affects the length an entity waits in queue. The methodology involved starting at 12 workers and adjusting from this number until the simulation produced reasonable queue times. It is important to keep in mind that these queue times reflect the turn-around time for invoices, GPC Statements, waiver paperwork, and reimbursement paperwork. They do not reflect an actual student waiting for service. Discussions with AF/DPLE revealed they were interested in analysis of the range of queue times seen in Table 17.

Table 17. Number of Workers Required at a Central Office

	Queue Times			
Month	**3 Days**	**1 Week**	**2 Weeks**	**4 Weeks**
June	16	15	13	10
July	15	14	13	12
August	15	14	13	12

Figure 17 illustrates graphically the data in Table 17.

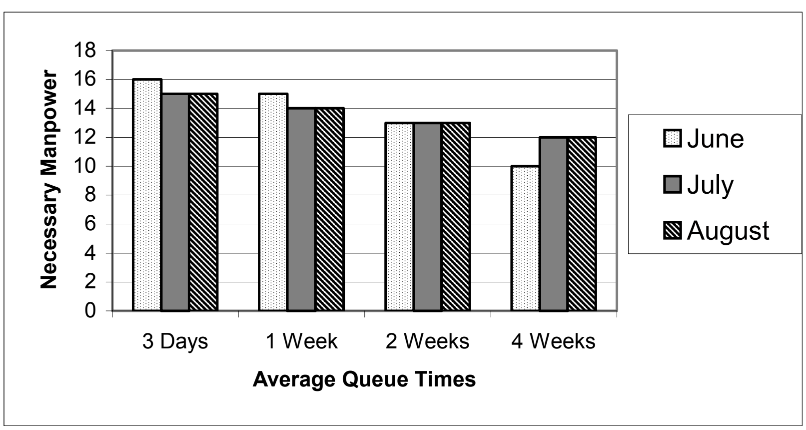

Figure 17. Manpower Requirements for the Central Office

AF/DPLE's interest in a 4-week queue time corresponds to the requirements under the 30-day Prompt Payment Act. Interest penalties apply to those payments exceeding this 30-day window. To ensure every invoice complies with the Prompt Payment Act, the maximum queue length is evaluated to derive manpower requirements. Table 18 shows the resultant analysis when the maximum queue length is used.

Table 18. Required Manpower at a Central Office with 4-Week Max Queue Time

	Required Manpower
June	11
July	12
August	12

This analysis had little impact on the resultant manpower requirements.

An analysis of the anticipated manpower savings at the base level (Table 15), coupled with the manpower required to manage a central office, yields a robust estimate for manpower savings expected through centralization. Table 19 illustrates the approximate manpower savings based on each queue length.

Table 19. Anticipated Manpower Savings through Centralization (in people)

Queue Length	3 Days	1 Week	2 Weeks	4 Weeks
June	6	7	9	12
July	20	21	22	23
August	29	30	31	32

The values for this table were calculated by taking the average manpower savings at the base level (rounded to the nearest integer) and subtracting the number of workers needed for a central office configuration under the corresponding queue lengths. Under the central system approximately 39% of the manpower is utilized for the processing of applications while under the current system approximately 52% of the manpower is

utilized for this same function. This is the main reason August, with the highest arrival rate of applications, tends to have the greatest manpower savings between the current and the central system.

In order to validate the results, a comparison with the Navy and Marines central office is accomplished. The Navy and Marines currently man a central office together with 12 personnel: eight for the Navy and four for the Marines. The number of enrollments and the TA dollars issued annually were gathered to make a suitable comparison. Table 20 illustrates the information gathered. A value of 12 workers for the Air Force's central office was utilized because this is the worst-case scenario for a queue time of less than 4 weeks.

Table 20. 2001 Service Comparison for Central Office (Dantes VolEd Website, 2002)

Service	TA Dollars ($M)	Enrollments	Central Office Manpower	Dollars/ Manpower Ratio ($M)	Enrollments/ Manpower Ratio
Air Force	64.1	247,574	12	5.34	20,631
Navy	38	193,776	8	4.75	24,222
Marines	17.4	61,713	4	4.35	15,428

The *dollars/manpower ratio* indicates a dollars per manpower statistic, or the number of TA dollars each person handles at the central office. This indicates a person is required at the Marines central office for every $4.35M in TA actions. The *enrollments/manpower ratio* indicates the number of enrollments each person handles at the central office. This statistic illustrates a person is required at the Navy central office for every 24,222 enrollments. The Air Force's ratios are very comparable to the Navy and Marines. This analysis helps to validate AF/DPLE's proposal estimates of the

manpower required at a central office. This assumes an average queue time of 4 weeks. Requirements for a smaller queue length would require additional manpower.

The experiences of the Navy and Marines enabled us to narrow our search of potential cost saving areas under centralization. Specifically, the Navy and Marines experienced tremendous cost savings in the area of reimbursements. The reimbursements returned to the government drastically increased in the years after centralization took place. According to Navy and Marine personnel, this is attributed to the more rigid approach in dealing with waivers and reimbursements (Giorlando, 2002). The Air Force intends to enforce this same policy in handling waivers and reimbursement as it hopes to realize similar cost saving benefits. This assumption was built into the central model, as explained in the model building section of this chapter. The number of expected reimbursements are tallied through the simulation and averaged for each of the 30 replications. This average number of reimbursements is multiplied by the average reimbursement amount ($219.09) for a total expected reimbursement amount of $2,255,677.68. This number represents a close approximation of the dollar value expected in reimbursements between the months of March and August. This is under the assumption the Air Force collects reimbursements from all students who do not successfully pass their course and do not have an AFI-approved waiver reason. The Air Force actually collected $1,140,529.39 between the months of March 2002 and August 2002. This amounts to a difference of $1,115,148.29. The analysis was limited to a six-month period due to the data limitation. Twice this amount, $2,230,296.58, gives a rough estimate of the annual savings expected through centralization.

This concludes the analysis of the output data from the simulation models. Further interpretation and conclusions drawn from these results follow in the concluding chapter. For this reason, the final step (Step 10), Document, Present, and Use Results, is not detailed in this chapter.

5. Centralization and the PPBS Process

5.1 Chapter Overview

In Chapter 2, a detailed discussion of the PPBS process and how it operates is presented. The PPBS and funds execution side of TA are both affected by centralization. These two aspects of centralization represent the funds planning/budgeting phase and the subsequent execution of these funds. This chapter explains why a specific methodology did not fit in the analysis of centralization with regards to the PPBS process. Second, the chapter focuses on the improvements expected in the management time of the PPBS process under centralization. Third, the discussion concentrates on how centralization can positively or negatively affect other areas of the PPBS process. Finally, a summary of the analysis of centralization with regard to the PPBS process is presented.

5.2 Methodology for Determining Processing Time Improvements

Originally, the research effort involved the development of a simulation for the PPBS process to determine if improvements in processing times under a central system may be realized. However, as the simulation developed, it became obvious there was no need to accomplish a simulation. Rather, the question is answered intuitively. As described in Chapter 2, the current system works through estimation and budgeting for future fiscal year requirements at the lowest levels with aggregation occurring at both the MAJCOM and Air Staff levels. Under this system, multiple government employees at various levels spend countless hours compiling information and data for inputs to the PPBS process. Centralization is meant to eliminate this work at the lower levels. Through centralization, Air Staff personnel can mine data from the AFAEMS database to

obtain an estimate for future year requirements. Therefore, the required PPBS numbers are accomplished through a quick data extraction from AFAEMS, resulting in a drastic reduction in processing time.

The main limitation is not being able to understand the extent of the savings in processing time or manpower requirements. Our initial research found that to estimate the time each of the 82 individual bases and the 7 MAJCOMs take to accomplish this tasking is a flawed undertaking. The flaw occurs because there is not a standardized process across the 82 bases and 7 MAJCOMs. Each base and MAJCOM approach the input estimates in a unique way and year after year different processes are accomplished in this tasking. It is for this reason the simulation did not reach fruition. The study concludes savings in processing times certainly occur through centralization based on a simple network analysis of the problem and through the advantages of a central database. Figure 18 depicts the flow of PPBS inputs in the current system.

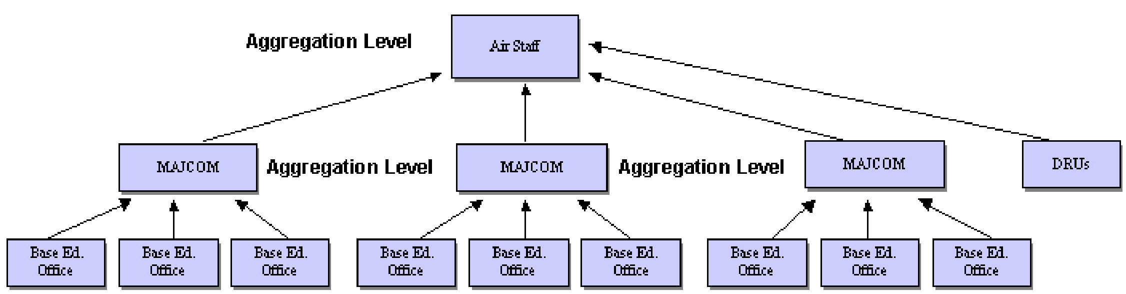

Figure 18. Flow of Required Inputs to the PPBS Process

Centralization provides a central database for direct analysis (one person/one process) used in necessary PPBS inputs.

5.3 Other Expected Outcomes with Centralization

In addition to the processing time, AF/DPLE is concerned with accuracy gains and consistent policy enforcement. It is beyond the scope of this research effort to detail the potential gains or losses in the area of accuracy. Estimation at the lowest levels should provide the greatest insight to future years' needs. The effects of situations like school closures, credit hour rate increases, fluctuations of base personnel and deployments may be easier to incorporate at a more intimate level, like that of the Base Education and Training Flights. However, the effect of a multitude of different processes and various estimation techniques used to estimate a portion of a much larger figure is unknown. In addition, it is uncertain the affect aggregation at the MAJCOM and Air Staff levels has on the accuracy of the PPBS inputs. Further research should include analysis on the accuracy affects of a decentralized versus a centralized approach in the planning and budgeting of government dollars.

The final area of concern is the issue of consistent policy enforcement. As mentioned in Chapter 2, when funds run out at the base levels, the ESOs are faced with the decision of breaking the Anti-Deficiency Act or denying TA funds to students, neither avenue being a desired outcome. While certain bases face this dilemma, others have an adequate supply of funds, leading to an equity issue for the Air Force member. In addition to this, AF/DPLE has found that some bases use TA funds to purchase items that indirectly support TA functions (e.g. computers) (AF/DPLE, 2002). These actions are in direct violation of TA policy but since the money is distributed down to the bases, AF/DPLE has little control over the funds once they have left the Air Staff level. Centralization can solve these problems. First, through centralization, ESOs never face

the situation of dwindling funds. This is because the funding is located at the Air Staff level. Every student in the Air Force has the same opportunity to take advantage of TA funds because they are distributed on a first come first serve basis. In addition, the resolution of inadequate funding would most likely be very swift, as TA is a must-pay bill. Failure to resolve a shortage in funding would result in a shutdown of TA across the Air Force. Finally, the centralization of funds would also eliminate the usage of TA funds for other than actual TA commitments at the base level, as bases would no longer have control over these funds.

5.4 Conclusion

This discussion of how centralization affects the PPBS process is provided to give the reader a full understanding of all sides of the issue. The crux of this thesis has focused on the funds execution aspect of TA centralization, but certainly the ideas contained herein have explored avenues the simulation could not properly address. The solutions to some of these problems are more qualitative than quantitative in nature and often carry the added burden of being political.

6. Results and Recommendations

6.1 Importance of Findings

The results from this research should help the Air Force make an informed decision for the future organizational structure of the TA program. This structure impacts manpower, funding, and customer service. The output from the two models constructed for this effort quantify potential gains and losses for the Air Force as a result of a substantial organizational structure change. This research has also provided insight into the feasibility of the AF/DPLE's proposed design. The analysis of this problem should help answer the question of whether or not centralization is the best step for Air Force TA efforts. This is a decision that cannot feasibly be reversed. The outcome of this decision could be quite costly to the Air Force in terms of dollars, manpower, and potential service affects on the student. It is important for the Air Force to weigh the potential gains from each system configuration with the aim of making an informed decision.

6.2 Limitations

The analysis of this problem was limited only by what the simulation could offer. As discussed in Chapter 4, the simulation offered insight into the potential processing time improvements (translated into manpower savings), manpower needs at a central office, and potential cost savings in the form of reimbursement dollars. Most of the analysis in this thesis effort focused on quantitative savings. The potential qualitative impact to the customer was not explored in this research. In other words, it is not certain whether centralization would positively or negatively impact the customer service provided to Air Force men and women.

When processing times were constructed for the central model, the SMEs used their current knowledge of the process to construct appropriate distributions. This analysis did not look into the potential improvements in processing times as a result of central office personnel performing their functions in a different environment. In other words, the effects of personnel working one type of tasking (e.g., processing invoices) repetitively and without some of the interruptions that would be expected at the base level office was not explored in this research.

The PPBS process and the potential gains in centralizing this effort for TA was qualitatively addressed in Chapter 5; however, a direct quantitative assessment was not accomplished. This thesis effort did not address what affects centralization might have on the accuracy of the inputs to the PPBS process.

6.3 Results

The output from the two simulations constructed for this analysis demonstrated a significant savings in processing times under centralization. For the months analyzed, manpower equivalent to at least 21 people might be saved Air Force wide through centralization. However, it is not the intention of this analysis to take away manpower from the bases. Severe manpower reductions have already taken place as a result of the A-76 studies mentioned in Chapter 1. The following table gives a snapshot of the number of positions per MAJCOM already lost due to A-76 Studies.

Table 21. Positions Lost through A-76 Studies (AF/DPLE, 2002)

MAJCOM	Positions Lost
ACC	73
AFMC	7
AMC	26
PACAF	26
SPACE	22

The large discrepancy in positions lost is due in large part to the fact that A-76 Studies are still ongoing. Some of these MAJCOMs are just beginning to experience the affects of the A-76 Studies (AF/DPLE, 2002). The reductions in manpower have largely affected the base level organizations. Personnel at the base level are finding it hard to accomplish their required taskings while still maintaining the same quality counseling services they have in the past (Base Education and Training Flights and MAJCOM Representatives, 2002). Centralizing some of the base level transactions should help alleviate the manpower crisis being experienced at Base Education and Training Flights throughout the Air Force. One of the largest selling points for the Air Force is its quality education initiatives. Centralizing TA efforts is an avenue that should free up manpower to concentrate on providing quality counseling services for Air Force men and women.

The simulation for the central system attempted to verify AF/DPLE's proposed manpower configuration at a central office. The analysis provided a number of answers depending on the turn around time necessary in performing the functions at the central office. The simulation indicated the number initially proposed by AF/DPLE is adequate under the assumption of an average 4-week queue time. Whether this turn around time is sufficient to meet the needs of this organization is up to the decision maker. Additional analysis was provided for varying queue length in the event AF/DPLE finds they are

concerned with potentially slow turn around times. Every simulation is subject to errors because no simulation can model a system exactly. For this reason, the most practical information that can be taken away from this analysis is the initially proposed number of 12 workers does not seem to be unrealistic. In assessing the validity of the centralized concept, AF/DPLE is now aware their initial proposal was a valid one. However, this is under the assumption of a four-week queue time. If AF/DPLE determines later that a smaller turn around time is required for the paperwork at the central office, then additional manpower will be necessary to successfully manage this office.

Analysis in Chapter 4 also provides a rough estimate of the annual savings expected through centralization. This figure amounted to approximately $2.23M annually. However, this number reflects what may have been saved in the year 2002. On 1 October 2002, 100% TA was initiated. Prior to this date, TA only covered 75% of the school expenses. It can be safely assumed this figure could increase by as much as 33%, to almost $3M, due to this increase in TA coverage. This does not even reflect potential increases in enrollments due to this new policy. Initial estimates reveal that enrollments have increased by as much as 61% due to the new policy. The savings from reimbursements could amount to as much as $5M annually with enrollment increases reaching all time highs.

6.4 Future Research

Future research efforts should explore the effects of centralization on processing times, accuracy, and standardization. As discussed in the limitations section, there is no analysis accomplished in the area of processing time improvements as a result of a

centralized environment. Future research could focus on how the environment of a central office might affect the performance of workers. The Navy and Marines as well as other organizations and companies that have already implemented a centralized office could provide the necessary data and information for further analysis.

Future research might involve analyzing the effect on accuracy in the planning and budgeting of government dollars between a centralized and decentralized system. It would be important to defend any potential negative affects to the accuracy of PPBS inputs by showing the potential gains in processing times. Determining to what extent positive gains in one area outweigh negative impacts in another area is customer dependent. These areas of future research address many of the limitations described previously.

6.5 Conclusions

The results and conclusions drawn from this research effort are intended to provide AF/DPLE with insight into their decision about centralizing TA efforts. The output from the simulation models and the conclusions drawn from the analysis rely heavily on the information provided by AF/DPLE SMEs. The findings of this analysis indicate that centralization provides significant savings in the form of manpower, processing times, and TA dollars. However, the qualitative and possible political impacts such a large organizational restructuring might bring must be weighed against potential gains. This tasking is rightfully left to the customer.

Bibliography

1. A-76 website. "An Overview of the A-76 Process." Informative website. n. pag. http://emissary.acq.osd.mil/inst/share.nsf/CONTDEFLOOK/About+A-76-Process+Overview#steps. 15 July 2002.

2. AF/DPLE, Personal Interviews and correspondence with Marylee Baker, Jim Sweizer, Kendall McAree, George Barborak, and John Hill. July 2002 through January 2003.

3. Aguilar, Marc, Tankred Rautert, and Alexander J. G. Pater. "Business Process Simulation: A Fundamental Step Supporting Process Centered Management". Proceedings of the Winter Simulation Conference. December 1999.

4. Ahlfors, Ulla, Jonna Kalermo, and Timi Karkkainen. "Dell's Approach to ERP: Dell Direct Model." University of Jyvaskyla. 4 August 2000.

5. Amoco Corporation. "A Customer Success Story." Article by FileNET corporation. http://www.filenet.com/English/Customers/Global-English/Success_Stories/020110004.pdf. 11 December 2002.

6. Baker, Marylee, AF/DPLE. Staff Summary Sheet on Centralization of Air Force Tuition Assistance. Pentagon, Arlington, VA. 22 October 2001.

7. Barjis, Joseph, Jan L. G. Dietz, and Luuk P. J. Groenewegen. "Organizational Simulation – Concept & Application". From the Summer Computer Simulation Conference. Vancouver, B.C. July 2000.

8. Barry, John, Brig Gen. "Who's in Charge? Service Administrative Control." Paper written Fall 1998. http://www.airpower.maxwell.af.mil/airchronicles/apj/apj98/fal98/barry.pdf. 11 December 2002.

9. Base Education and Training Flights and MAJCOM Representatives, Personal Interviews with Jeannie McFadden, Donna Gibbs, Sherry Brown, Dolores Johnson, Donna Ray, and Richard Smith. July 2002 through August 2002.

10. Dantes VolEd Website, "DoD Voluntary Education." Informative website. n. pag. http://www.voled.doded.mil/voled_web/voledhome-text.asp?Flag=True. 15 December 2002.

11. Defense Systems Management College. *Fundamentals of Business Financial Management Course* text. January 2001.

12. Department of the Air Force. *The Education Services Program.* AFI 36-2306. Washington: HQ USAF/DPDL. 16 October 2000.

13. Department of Defense. *Financial Management Regulation Volume 14 – Administrative Control of Funds and Antideficiency Act Violations.* DoD 7000.14-R. March 1998.

14. Fogleman, Ronald R. and Sheila E. Widnall. "Air Force Issues Book 1997." Unpublished report. http://www.af.mil/lib/afissues/1997/issues.pdf. 25 August 2002.

15. Giorlando, Charles. Systems Manager, Navy Campus Management Information System, Pensacola, FL. Personal Interview. 30 July 2002.

16. Keating, Patrick C., Colonel. Memorandum for MAJCOM Education and Training Directors, Subject: Air Force Tuition Assistance (TA) Policy (Nr. 2002-08). 6 May 2002.

17. Kelton, David W., Randall P. Sadowski and Deborah A. Sadowski. *Simulation with Arena* (2nd Edition). New York: McGraw-Hill Companies, Inc. 2002.

18. Law, Averill M. and David W. Kelton. *Simulation Modeling and Analysis* (3rd Edition). Boston: McGraw-Hill Companies, Inc., 2000.

19. Lind, Mikael. "Dividing Businesses into Processes – Foundations for Modeling Essentials." Presented at the IFIP WG 8.1 Working Conference on Organizational Semiotics. Montreal, Quebec. July 2001.

20. McCain, John. Excerpt from press release. http://mccain.senate.gov/brachilloped1.htm. 15 July 2002.

21. Myatt, Clark E. Vice President Al Gore's National Performance Review. Write up for the Hammer Award Nomination Package. 30 June 1997.

22. Office of Management and Budget. *Circular No. A-76 & Supplemental Handbook* http://www.whitehouse.gov/omb/circulars/a076/a076.html. 4 August 1983 (Revised 1999).

23. Pegden, C. E., R. E. Shannon, R. Sadowski. *Introduction to Simulation using SIMAN* (2nd Edition). New York: McGraw-Hill, 1995.

24. Taylor, Vernon. Systems Manager, Marines Campus Management Information System, Pensacola, FL. Personal Interview. 30 July 2002.

Vita

Captain Tamiko L. Ritschel graduated from Centennial High School in Gresham, Oregon in 1993. She attended the University of Notre Dame in South Bend, Indiana where she received a Bachelor of Science in Mathematics in 1997. She was commissioned through the AFROTC program at the University of Notre Dame, Detachment 225.

She launched her active duty service at Barksdale AFB, LA in July of 1997, where she began training as a contracting officer. While stationed at Barksdale AFB, she deployed twice to South America as a contingency contracting officer in support of Operation Constant Vigil. In August of 2000, she was assigned to the B-2 System Program Office, Aeronautical Systems Center, Wright-Patterson AFB, OH. In September 2001, she began her master's studies at the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, she will be assigned to the Air Force Logistics Management Agency, Maxwell-Gunter AFB, AL.

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 074-0188*

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to an penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From – To)*
03-25-2002	**Master's Thesis**	Jun 2001 – Mar 2002

4. TITLE AND SUBTITLE	
A SIMULATION COMPARATIVE ANALYSIS OF ALTERNATIVES FOR TUITION ASSISTANCE ORGANIZATIONAL STRUCTURES	**5a. CONTRACT NUMBER**
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	**5d. PROJECT NUMBER**
Ritschel, Tamiko, L., Captain, USAF	**5e. TASK NUMBER**
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)	**8. PERFORMING ORGANIZATION REPORT NUMBER**
Air Force Institute of Technology Graduate School of Engineering and Management (AFIT/EN) 2950 P Street, Building 640 WPAFB OH 45433-8865	AFIT/GOR/ENS/03-20
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	**10. SPONSOR/MONITOR'S ACRONYM(S)**
AF/DPLE Ms. Marylee Baker DSN: 225-7586 e-mail: Marylee.Baker@pentagon.af.mil	**11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

12. DISTRIBUTION/AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The military services have experienced enormous downsizing efforts in the last decade. With these initiatives, organizations have had to derive innovative ways to meet their objectives with fewer resources. An organization's structure is an avenue to address these challenges within the atmosphere of a shrinking capital budget. Organizational structure changes can affect every aspect of the organization. Such an impact suggests proposals for drastic organizational changes must meet the rigors of a full analysis.

The intent of this research is to provide a comprehensive analysis of centralization options for Air Force Tuition Assistance efforts. This thesis effort involves the development and subsequent analysis of multiple simulation models. The models provide insight into whether centralization will produce savings in processing times, manpower, and cost.

Results show that centralization will positively impact the Tuition Assistance organization in meeting their objectives while allowing the Air Force to take advantage of efficiencies through technological advancements.

15. SUBJECT TERMS

Tuition Assistance, Simulation, Organizational Structure, Reorganization, Business Process Reengineering, Organizational Realignment, Arena, Input Analysis, Organizational Design

16. SECURITY CLASSIFICATION OF: U			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Paul W. McAree, Maj, USAF (ENS)
U	**U**	**U**	**UU**	91	**19b. TELEPHONE NUMBER** *(Include area code)* (937) 255-6565, ext 4324; e-mail: Paul.McAree@afit.edu

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18